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A SURVEY OF PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY; MEASUREMENT AND CAUSES

A Special Research Problem

Presented to

The Faculty of the School of Civil Engineering
Georgia Institute of Technology

by

Peter Morris Arn

In Partial Fulfillment
of the Requirements for the Degree of
Master of Science in Civil Engineering

December, 1987

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

T234915

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TABLE OF CONTENTS

Page
ACKNOWLEDGEMENTS.................................. iv

ABSTRACT v

CHAPTER I PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY

INTRODUCTION 1
HISTORY OF PRODUCTIVITY TO PRESENT 1
IMPORTANCE OF PRODUCTIVITY ON SOCIETY........ 2
    DECLINE OF PRODUCTIVITY IN THE U.S. 4
    ANALYSIS OF REASONS FOR THE DECLINE 7
DIRECTION OF CONSTRUCTION PRODUCTIVITY 11
    JAPANESE PRODUCTIVITY CENTERS 12
    AMERICAN PRODUCTIVITY CENTERS 13

CHAPTER II PRODUCTIVITY MEASUREMENT IN CONSTRUCTION

INTRODUCTION 16
DEFINITION OF PRODUCTIVITY IN CONSTRUCTION... 17
    GOVERNMENT DEFINITIONS 18
    INDUSTRY DEFINITIONS 20
IMPORTANCE OF PRODUCTIVITY MEASUREMENT....... 22
    ESTIMATING AND PROFITS 22
    COST ACCOUNTING 24
MEASUREMENT TECHNIQUES 25
    HISTORICAL 27
    SCIENTIFIC 28
MEASUREMENT OF OUTPUT 32
    EARNED VALUE 33
    ESTIMATED PERCENT 37
    PHYSICAL MEASUREMENT 39
MEASUREMENT OF INPUT 40
    MANHOUR METHOD 41
    DOLLAR METHOD 44
PERFORMANCE EVALUATION TECHNIQUES 45
    PERFORMANCE FACTORS 46
    INPUT UTILIZATION 48
WHITE COLLAR PRODUCTIVITY MEASUREMENT 63
    COMMITMENT TECHNIQUE 64
    PERFORMANCE EVALUATION 65

CHAPTER III INFLUENCES ON PRODUCTIVITY IN CONSTRUCTION

INTRODUCTION 68
OPPORTUNITIES FOR IMPROVEMENTS 69
CURRENT INDUSTRY RESEARCH AND DEVELOPMENT ... 72

TABLE OF CONTENTS CONTINUED

UNIONS AND OPEN SHOPS 75
GOVERNMENT 80
ENGINEERING AND DESIGN STANDARDS 84
    CONSTRUCTABILITY 84
    VALUE ENGINEERING 87
ROBOTICS 89
SAFETY 91
OVERTIME 93
WEATHER 95

CHAPTER IV HUMAN INCENTIVES AND MOTIVATIONS

INTRODUCTION 97
THEORY'S 98
    MASLOW HIERARCHY 98
    THE X AND Y THEORY 99
    EXPECTANCY THEORY 104
    NEEDS 105
LABOR STUDIES 107
WHITE COLLAR STUDIES 112
SELECTION METHODS 114

CHAPTER V CONSTRUCTION MANGERS PRODUCTIVITY PLAN OF ACTION

INTRODUCTION 119
18 POINT PRODUCTIVITY PROGRAM 120
    COMMUNICATION 121
    LEADERSHIP 124
    PRE JOB SET UP 125
    SELECTION AND PLACEMENT 127
    TRAINING AND EDUCATION 128
    GOAL SETTING 130
    MANAGEMENT BY OBJECTIVES 131
    SUPERVISORY METHODS 133
    SAFETY 134
    APPRAISAL AND FEEDBACK 135
    DECISION MAKING TECHNIQUES 136
    CAREER DEVELOPMENT 137
    ORGANIZATIONAL STRUCTURE 138
    FINANCIAL COMPENSATION 139
    PHYSICAL WORKING CONDITIONS 140
    WORK RESCHEDULING 141
    WORK REDESIGN 142
    JOB SECURITY 143

TABLE OF CONTENTS CONTINUED

CHAPTER VI CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS 145
RECOMMENDATIONS 148

BIBLIOGRAPHY 149

APPENDICES

A. LIST OF PRODUCTIVITY CENTERS AND RESEARCH INTUITIONS CONTACTED.
B: LIST OF INTERVIEWS

ACKNOWLEDGEMENTS

It has been a great experience spending the last year at Georgia Tech. There are many people I owe a great deal of thanks to in helping me gain a better understanding of the Construction Industry.

First, I wish to thank the U.S. Navy for providing this great opportunity.

Second, I wish to thank the facility at Georgia Tech. for there time and assistance, especially Dr. Leland Riggs for his guidance and knowledge.

Finally and most importantly my Family without whom my existence would be meaningless.

Peter M. Arn

ABSTRACT

This paper examines and discusses the current status of productivity in the construction industry from the Construction Manager's perspective. The paper deals mainly with labor productivity within the construction industry and briefly discusses "White Collar" productivity.

Chapter one will review the recent history of productivity in the construction industry, the importance of productivity in society and views as to why some people are concerned about the current state of affairs. From understanding the current status chapter one will talk about the direction the industry is heading and elaborate on current developments.

Chapter two goes directly into the methods of productivity measurement starting out with the various industry and governmental definitions to the latest performance evaluation techniques. Chapter two will tie together the importance of productivity with estimating, profits, and accurate cost accounting.

Chapter three will discuss in depth the many influences on productivity within the construction industry. It will attempt to dispel some of the current myths and excuses and provide an accurate overview of potential impacts from numerous new developments.

Chapter four will investigate the human incentives and motivations that influence the human productivity on the job site and in the office. This will start out with a quick review of current human motivational theories and develop into a more

detailed review of the recent studies performed on the job sites throughout the United States.

Chapter five will provide a comprehensive 18 point program of action for the construction manager to implement in the field or in the office to increase productivity on various job sites.

CHAPTER ONE

PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY

INTRODUCTION

Productivity in the construction industry affects every aspect of our daily lives, it contributes to our standard of living, impacts the nations economy and sets the direction for our future. The purpose of this paper is to heighten our understanding of productivity in the construction industry from the construction managers point of view. Using the definition of Polly Scott, the construction manager throughout the paper is meant to be a professional project manager. The construction manager works with the owner and the design organization from the beginning of the design through the completion of the project. He provides leadership to all the separate components of the project including the construction team and the management team. He is technically proficient in construction technology, project management, and procurement [Scott and Schowalter, 1986]. This paper assumes that all the readers are familiar with the construction terms used and with construction productivity in general.

HISTORY OF PRODUCTIVITY

In 1983, the Business Roundtable concluded a four year study on the construction industry and its practices. The study started in 1969 when the Construction Users Anti-Inflation Roundtable committees were formed. These committees were formed out of concern and necessity because the cost of construction was skyrocketing compared to the rest of the economy.

The concern for construction productivity and cost are not new to the late 20th century. It dates back more to the days of Jericho in the year 7800 B.C. Countless professional studies have been completed and forgotten and some have even managed to stay with us to now, Thomas Mason from 1792, more specific to the construction industry, Frederick Taylor from the late 1800's, and Frank Gilbreth who in 1909 published a book of bricklaying systems. On a more famous note, of course, there is the work of Henry Gantt who developed the now widely used Bar Chart in 1908 [Drewin, 1982]. The strangest result that came from all the studies in the early 20th century is that most of them were done as an analysis of construction activities. However, all the lessons learned over time have been successfully applied to manufacturing but construction continues to have the same problems as it did in the early half of the century when the studies were done.

The most recent concern for productivity in the construction industry is well founded. Since 1909 manufacturing productivity per man-hour has increased 2.6 times faster than that of the construction industry, this lack of increase in the construction industry has had a great effect on our society [Parker, 1972].

IMPORTANCE OF PRODUCTIVITY ON SOCIETY

As our nation continues to increase or at least maintain our standard of living we continually try to seek the best use of our national resources and to maintain our competitiveness at home and overseas. Productivity of the American economy is of a major concern to all Americans and to civilized society in general.

The level of productivity in the work place is closely tied to the quality of life in America. The level of productivity affects not only our personal security and well being of individuals but also that of society.

The rest of the world still measures themselves against the average American worker, and strives to exceed our levels of output which then affects the way we live our daily lives. Several countries have exceeded our per worker output [BLS, 1987]. Productivity is not the new catch word of the 80's, it has been and will remain of great importance to any industrial nation. Productivity sets the pace of our economy. The reason productivity has gotten so much attention in the United States industry over the last two decades is because the productivity increase of the United States has been small or negligible. Over the last couple of decades the productivity rate of the United States compared with the other industrialized nations has been very alarming. However in the last serval years the news has been pretty good. The latest reports from the U.S. Bureau of Labor Statistics show "Manufacturing productivity rose 3.5 percent in the United States from 1985 to 1986, and, while the U.S. 1986 increase was less than in 1985, it was well above the U.S. trend rate from 1973 and exceeded the productivity gains recorded by any of the other nine Countries."[BLS, 1987] The good news for the last two years is encouraging. However, it does not make up for the years of slow growth in productivity, nor does it mean the construction industry has increased its productivity rate.

DECLINE OF THE PRODUCTIVITY RATE IN THE U.S

Before beginning an indepth review of the productivity rate in the construction industry for the last serval decades it is important at this point to understand just why productivity in the construction industry is so vital to the national productivity level and to the nation.

According to the National Research Council, the construction industry accounted for 8.5% of the GNP in 1984. The dollar value of the construction was estimated at $313 billion.(see table 1) The National Research Council admitted that this is a conservative figure since defining and measuring the size of the construction industry is difficult because of its fragmented nature and because construction activities frequently overlap into other industries. For example, construction contracts that call for the installation of carpeting, home appliances, and telephones are not counted in the government estimating. The labor force accounts for 8% of the national work force or more than 8.6 million workers. There are almost 1 million general and specialty contractors in the construction industry, over 50,000 architect and engineering firms, over 25,000 building material dealers, 15 major building and construction unions, and 180 construction related trade associations. As can be seen from the magnitude of size of the construction industry when the productivity level is not increasing with the rest of the nation, or for that matter with the rest of the world, there is a problem [NRC, 1986].

From 1960 to 1973 productivity in the United States rose

TABLE 1 Value of New Construction Put in Place in 1984 (millions of current dollars)

Type of Construction	Value
Private Construction	
Residential buildings:	
New housing units	114,620
Non housekeeping (e.g. hotels)	7,000
Additions and alterations	23,440
Total	145,059
Nonresidential buildings:	
Industrial	13,745
Office	25,940
Other commercial	22,167
Religious	2,132
Educational	1,411
Hospital and institutional	6,297
Miscellaneous	2,455
Total	74,147
Farm nonresidential	2,860
Public utilities:	
Telephone and telegraph	7,174
Railroads	3,671
Electric light and power	19,473
Gas	3,233
Petroleum pipelines	271
Total	33,822
All other private	1,912
Total, private construction	257,801
Public Construction	
Buildings:	
Housing and redevelopment	1,636
Industrial	1,828
Educational	5,557
Hospital	2,039
Other	6,822
Total	17,883
Highways and streets	16,294
Military facilities	2,839
Conservation and development	4,654
Sewer systems	6,241
Water supply facilities	2,621
Miscellaneous public	4,654
Total, public construction	55,186
Total, all construction	312,987

SOURCE: Bureau of the Census (1985).

only 3.3% annually while other foreign countries had double or more our annual rate. The trend continued throughout the 70's and hit a low of 2.4% in 1978, rating the United states sixth out of seven countries for increase in productivity.

The U.S. Department of Commerce report on productivity for individual industries shows clearly the main drag on productivity is the construction industry.(fig 1) The numbers in the figures must been taken only as a trend indicator since estimation of construction productivity is not precise.

INDUSTRY	% PRODUCTIVITY INCREASE
Agriculture	3.64%
Construction	0.80%
Government	1.64%
Manufacturing	2.60%
Mining	3.17%
Public Utilities	5.40%
Transportation	4.60%

(Figure 1) Annual Productivity Increase by Industry for 1970 thru 1980. [Adrian, 1982]

The figures presented by the Government are impressive, however, for the most part inaccurate according to the Business Roundtable. "It found that the government does compile construction productivity indexes, but their accuracy is subject to serious doubts, partly because of the apparent under reporting

of the total value of construction put-in-place, and partly for technical statistical reasons." [Summary, 1983] The report goes on to say they, The Business Roundtable, could not find any statistical concrete evidence that the productivity rate was decreasing but they could prove it was not increasing which in their report is just as bad. Part of the problem lies in the lack of productivity standards. The federal agencies collecting the data have concluded that an industry's ability to increase productivity is dependent on the degree that it can set productivity standards and measure them. Although the absolute numbers may be in error, the trend is clear in that the construction industry is having a productivity problem.

DIFFERING VIEWS ON THE DECLINE OF PRODUCTIVITY

The decline of the productivity rate in construction has many indicators, indexes, and ratings published and distributed, and some not published, by the U.S. Government and every other industrialized government throughout the world. The United States is not alone in feeling the impact of a decrease in the productivity rate. In Japan, the construction industry, which started suffering during the post oil crisis business slump, was saved by increased government spending on public works projects which started in 1976. Although saved by their governments spending they to have suffered with greatly decreased profit rates and deceasing labor productivity [Hippon, 1983].

There are numerous theories as to why the productivity rate in the construction industry has declined or at least failed to rise. The problem is a national concern to government, labor and

the industry. Each of the three segments are blamed in differing degrees in each theory about the decline of the productivity rate in construction. Some of the authors are very candid about the fact there is no single reason for the decline. Other authors single out one of the segments, government, labor, or the industry and criticize it. A lot of the authors, because of the influence of labor on productivity in construction, equate overall productivity with labor productivity. Most of the articles or books are variations of two prominent theories and one not so prominent theory.

The first theory is presented by Steven G. Allen [Allen, 1985] "Why Construction Industry Productivity is Declining". He felt the biggest factor in the decline was the reduction in skilled labor intensity resulting from a shift in the mix of output from large scale commercial, industrial, and institutional projects to single family houses. Through statistic studies he felt this accounted for 41% of the observed decline from 1968 through 1978. The other major contributing factors were Capital-Labor Ratio, Economics of Scale, Labor Quality, Percentage Union, and Regional Shifts. The more interesting figures the author presented was the number of establishments which grew by 30.2% while labor grew at just 19.5% This resulted in an 8.1% increase in average hours per establishment, which converts to a 1.6% decline in productivity. The other interesting statistic provided concerned the average level of schooling, age, and sex of the work force. All three of which have increased during the ten year period. The author converted these statistics into a

3.8% decline in productivity.

He also felt that the government's method for estimating the deflator used in the productivity formulations is in error. He provided statistical backup that the difference between the official deflator and a new deflator he proposes in the paper accounts for an additional 51% of the reported productivity decline. The other 8% he can't account for in his work.

The second theory is presented by Tucker and is centered around the idea that construction is getting more and more complex. The projects are increasing in size which is decreasing our expected productivity rates and increasing the cost of construction. Construction costs have risen at a rate approximately 50% higher than the inflation rate. Because of the increasing magnitude of project participants, which now numbers 20 for the average project, (see figure 2) the amount of theoretically available man-hours to put work-in-place is down to 20% on some projects.

Contributing to the decrease in construction productivity, is the disparity between wage increases and the lack of productivity increase, legal restrictions, educational processes, and project management [Tucker, 1986]. Many of the reasons that the author discusses for construction productivity decreases are valid and are examined in detail throughout the paper.

The third theory which is presented by Perlo is not widely known and is not supported by any statistical data. The author felt the reported productivity decrease is fabricated by the

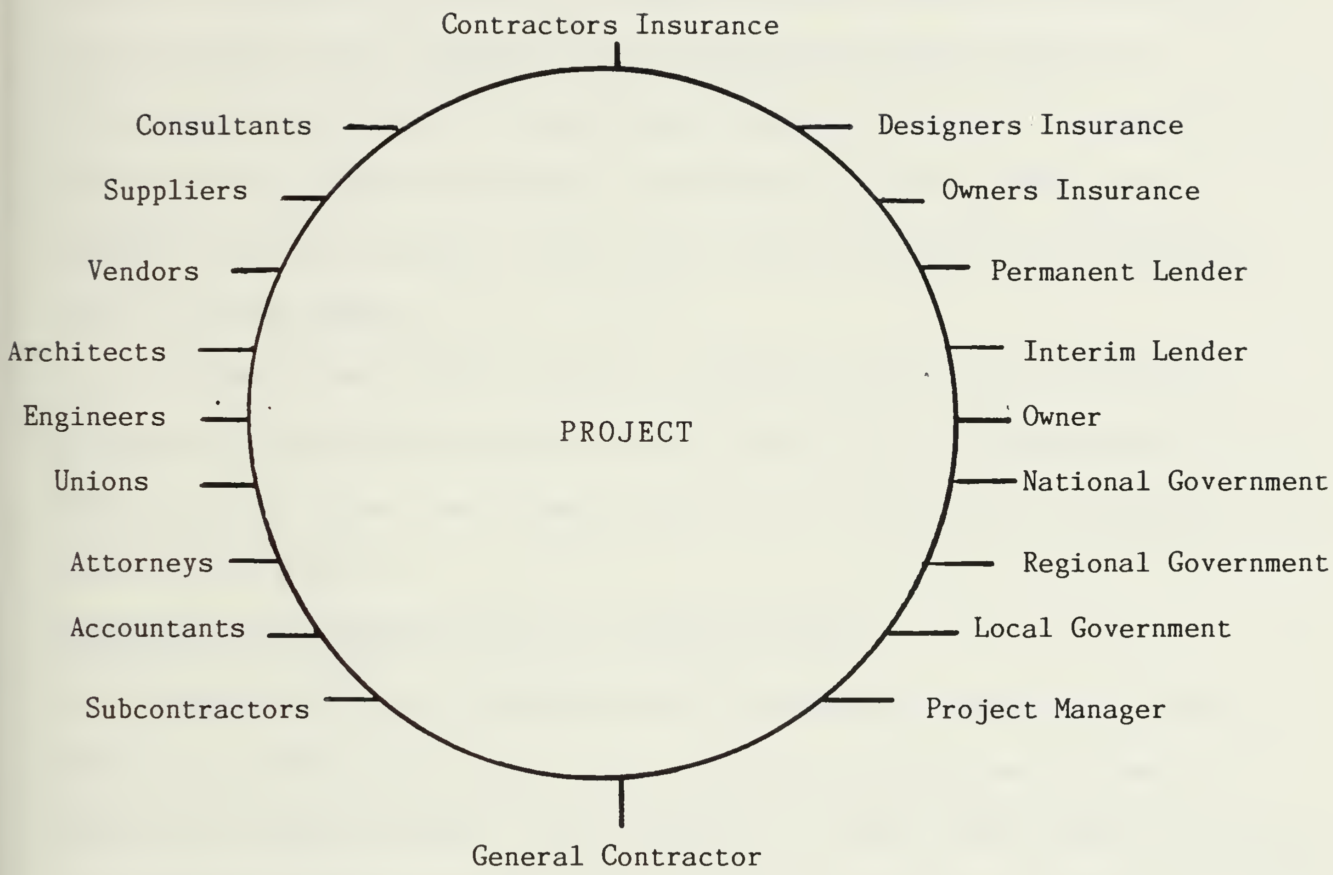


FIG. 2 - Project Participants

Federal Government and Wall Street as a means to justify wage decreases for the average working class citizen. Although the authors views are extreme he does present several interesting points which were addressed in the Business Roundtable's "Construction Industry cost Effectiveness Project". Several of the authors complaints about the Bureau of Labor Statistic methods for collecting data are valid and will be presented later in the paper.

The most important item to remember about the differing views as to why the construction productivity has declined, is no matter which theory one subscribe's to, the final recommendations are very similar.

DIRECTION OF PRODUCTIVITY IN CONSTRUCTION

The direction of productivity in general throughout the world is on the rise again according to the Bureau of Labor Statistics [BLS, 1987]. The numbers for the last couple of years as presented early in the paper are very promising for the United States. The question returns again very quick to how is the construction industry doing? The answer is usually, the industry must be doing better, the national productivity indicators are going up. We still cannot measure the productivity rate in the construction industry accurately. We have taken giant steps forward, however, in identifying our problems, advertising them, and working on solving them since The Business Roundtable published their reports on "The Construction Industry Cost Effectiveness Project". One day we will be able to estimate with a reasonable degree of accuracy the productivity rate in the

construction industry.

Since the publishing of the Roundtable reports numerous Productivity Centers have developed several dealing strictly with the construction industry. In researching this paper the author was in contact with many of the centers (appendix A) and reviewed their current activities. By far the center which has been functioning the longest was the Japan Productivity Center.

JAPANESE PRODUCTIVITY CENTER

Founded March, 1950 at the recommendation of the U.S. Government the center has set out from the beginning with a clear set of goals.

1. In the long run, improvement in productivity will increase employment.
2. In developing concrete measures to increase productivity, labor and management, conforming to the conditions existing in the respective enterprises, must cooperate in discussing, studying and deliberating such measures.
3. The fruits of improved productivity must, in correspondence with the condition of the national economy, be distributed fairly among management, labor and the consumer [JPC, 1986].

The Japanese productivity center has a 20 plus year head start in combining the efforts of management and labor at a national level. It is no longer individual companies making agreements with the labor force but whole industries with the aid of cooperation techniques and attitudes developed through programs like those offered at the Japan productivity center. In 1961 the U.S. Government withdraw its funding from the Japan Productivity

Center, however, by this time the center was fully supported by private industry. The Japan productivity center operates training centers for management and labor, sponsors overseas study teams with over 60 teams annually visiting the U.S.. They have over a ten million dollar budget annually for operations and research.

AMERICAN PRODUCTIVITY CENTER

The United States is not completely without its accomplishments in the area of productivity awareness and advances. The United States Department of Commerce has written a report on technological developments in the construction industry since the end of world War II. The author of this report asserts that the construction industry has made three major advances since WWII. The first being mechanization, the second new material developments, and the third prefabrication of structural components. The final point of the report is that although construction is not a high-technology industry it is technologically progressive [Newman, 1984].

The real start of a centralized awareness program started, as mentioned early, in 1969. In 1972 The Business Roundtable, now an association in which the chief executive officers of over 200 major corporations focus and act on a wide range of public issues, started its work on the Construction Industry Cost Effectiveness Project (CICE). The CICE project has been in progress for over eight years now with more than 250 people from the construction industry representing over 125 companies and universities. The CICE project produced 24 reports on varying

topics that affect the construction industry with a total of 223 recommendations for improvements. As an out growth of the CICE reports and to fill a void in the industry, the Construction Industry Institute (CII) was established. Started in 1983 CII brings together owners, contractors, and academia in an effort to develop information to improve the U.S. Construction industry. It coordinates its efforts through The Business Roundtable Advisory Council and the CICE Task Force [CII, 1986].

The CII deserves some discussion before we go any further. The CII believes that many of the problems that limit cost effectiveness are common to all organizations that share in the construction industry. It believes that real improvements can best be identified and accomplishments when made in a cooperative environment, with the benefits being shared by the construction industry at large. The sustaining membership in CII feels strongly enough to financially support CII with a annual membership fee of $25,000 and a commitment to support the activities of CII through participation.

The CII relations with the academic institutions is essential to accomplishment of its goals. At the end of 1986 there were 49 research contracts awarded and underway. The contracts all dealt in the following areas:

CICE Impact Evaluation
Productivity Measurements
Model Plant
Constructability
Industry Data and Statistics
Contracts
Cost/Schedule Controls
Materials Management
Design
Technology

Quality Management
Employee Effectiveness
Project Organization
Safety
Education and Training

An interesting note is that CII is discussing adding a task force on claims and liabilities.

All of the topics listed above directly or indirectly affect productivity in the construction industry. Some of the task forces are working on the problem of defining, measuring, and reporting productivity in the construction industry with some form of standardization.

CHAPTER TWO

PRODUCTIVITY MEASUREMENT IN CONSTRUCTION

INTRODUCTION

How do you define productivity? What does it mean in your own organization? What is the productivity level of your own organization or firm? How do you measure that productivity? What are the productivity inputs in your own organization or your segment of the industry? Does your organization have a stated set of productivity goals? Do you have a productivity program internal to your organization? How do your employees feel about that productivity program?

Most people cannot answer these questions. If they can answer the questions, the answers will vary depending on what level one ask them at within any organization. The truth is there is no common, widely shared industry definition of productivity. Productivity is paramount to any organizations success and survival and most people have a hard time defining it much less improving upon it. Consequently, there is no one best way of measuring a rise or fall in productivity. The first step to any productivity improvement plan is to define what we are measuring [Guzzo, 1983].

Productivity measures are used to make comparisons of technical efficiency across different production units for a given time period or across different time periods for given production units. The production process can be viewed as transforming certain inputs (land, labor, capital, and materials) into a good or service (such as a office building or a road).

Productivity is defined as the ratio of output to inputs [NRC, 1986].

In a complex industry such as construction it is entirely possible and probably quite likely that we will not have a single measure of productivity or single definition of productivity. There is nothing wrong with having multiple measures. So long as we are consistent in our understanding and use of the definitions.

DEFINITIONS OF PRODUCTIVITY IN CONSTRUCTION

In defining productivity we must get our semantics straight. What do we mean by productivity, performance, efficiency, effectiveness, and production?

Performance and productivity are not the same thing, a worker can work hard and have low productivity due to ineffective methods. Productivity can be high and performance low with the use of automated equipment. Worker performance traditionally is regarded as the product of ability and motivation, expressed as:

$$\text{PERFORMANCE} = \text{ABILITY} \times \text{MOTIVATION}$$

The multiplication sign in the equation is important because it shows that if either term is lacking then performance is nothing. Worker performance is an input to the productivity term.

Productivity and production are not exactly the same thing. Total production can go up with a increase in productivity of a single contributing input factor.

Productivity is the amount of goods and services produced by a productive factor in a unit of time. A single input resource. In its generic form:

PRODUCTIVITY = OUTPUT/INPUT

This definition leaves a lot of room for different applications, which is not totally unrealistic or bad. Each industry uses its own application of the term, and the government summarizes and uses its combined definition for that industry. The problem arises in that the construction industry has so many different applications and definitions and the government has never been able to come up with a good correlation of the various terms.

GOVERNMENT DEFINITION

The federal government through the Bureau of Labor Statistics using data from the Commerce Department is the primary source of national productivity data, but the accuracy and adequacy for the construction industry leaves much to be desired. However, with the proper rearrangement and correction in data reporting and collection techniques the potential usefulness should never be ignored.

The United States Department of Commerce defines productivity:

PRODUCTIVITY= DOLLARS OF OUTPUT / MAN-HOURS INPUT

In order to make relative comparisons from one period to the next, the federal statisticians adjust the numerator for the consumer price index. The Bureau of Labor Statistics (BLS) publishes productivity measurements quarterly for the total private business economy with major subdivisions using gross national product data for the output side of the ration. The BLS attempts to break this down into industry sectors ie..

manufacturing, transportation. The construction industry is one sector for which the BLS has constructed indexes of gross product originating per hour, however, they recognize that serious deficiencies exist in their measurements and have not published this report for several years. The gross product figures put together by the BLS come from the estimates for industrial and commercial construction figures reported by F.W. Dodge for contract awards.

To give an estimate of the error in the government reporting techniques the Business Roundtable studied in detail the governments figures and compared them with data collected from the industry in 1979. The report suggested that the governments official figures for total construction value should be increased by more than 30%, with almost all of the change in industrial, office, and commercial construction [Report A-1, 1982]. The findings of the Business Roundtable report are substantiated by the survey completed by Steven Allen [Allen, 1985] which was mentioned earlier. The author revised the governments method of estimating the deflator, by adjusting the contract awards based it on actual cost of projects versus that strictly for labor and materials. He accounted for 51% of the productivity loss by using this new deflator. This is one of the reasons that not much weight is placed on the absolute numbers concerning the decline of productivity in the construction industry anymore. However, the trend of rapidly increasing cost is still very apparent.

Within the government there are numerous ways to calculate

and monitor productivity within the private sector. The Federal Reserve Board publishes indexes of physical volume of manufacturing output which does not agree with the BLS. Using the Federal Reserve Boards numbers in the numerator it shows a increase of 50% in productivity between 1967 and 1980, compared with only 29% shown by the BLS reports. This is only one example of the disparities in the government reporting processes [Perlo, 1982].

It is obvious that there is a credibility problem with the government reports. The construction industry has the lions share of the problem and is currently working with the federal government through The Business Roundtable and the CII Task Force on Industry Data and Statistics. The results promise to be interesting.

Industry Definitions

When we consider the problem of coming up with an industry standardized definition of productivity the problem now branches out ten fold. How to define productivity for the construction industry on the lower levels. Returning to the generic definition of productivity we can develop numerous productivity terms for the construction site manager to use for more specific work activates for example:

LINEAR FEET/MAN-HOURS SQUARE FEET/MAN-HOURS

CUBIC YARDS/MAN-HOURS

Each craft within the construction industry has and can justify their own units in the productivity equation. This is more than reasonable but the problem develops how do we compare these

different crafts productivity rates with others and how do we sum all the crafts into a single productivity rate. Using DOLLARS/MAN-HOURS seems the most logical, however, each year the value of a dollar changes unevenly throughout the economy. Mr. McNair from Hardin Construction Company elaborated that even within his company there are different opinions on which measurement is best. To use DOLLARS/MAN-HOURS ones cost adjustments each year must be very accurate. On projects running over several years duration ones productivity rate would show great increases as the value of the dollar dropped but in reality the amount of work in place would have little change if no other variables had changed. No single criterion measure distinguishes itself as the most accurate, valid, or applicable to the productivity term when applied to the crafts. As stated before the author does not feel this is necessarily bad, if there was a single correct answer it would have been found long ago.

The secret to the industries success is going to be standardization of, and consistency with which terms are used. Such as for steel workers standardizing throughout the industry the productivity term of TONS/MAN-HOURS (just an example). Later on we can develop a conversion or relative weight factor for this definition of productivity to fit into the total productivity term. With the advent of the computers and the integration of the micro onto the job sites and offices this is no longer the impossible task. All of the companies interviewed were using or at least had micro computers at the job site.

This is not a new idea to the construction industry,

however, with the centralization of a couple of construction research institution this can become an industry standard for reporting. The definition of productivity must be set so we can go on with the business of measuring our productivity, which leads to the importance of measuring productivity.

IMPORTANCE OF PRODUCTIVITY MEASUREMENTS

The importance of productivity measurements can never be over estimated. Whether you do your own measurements or use one of the many published documents on productivity rates. Knowing accurately the productivity rate of ones own resources is the key to good estimating, and good estimating is the key to success in the construction industry. Simply put, estimating is the nuts and bolts of the construction industry.

ESTIMATING AND PROFITS

The preparation of accurate estimates leads to the success or failure of the project, either financial profit or loss. Alot of time and money goes into preparing a bid or estimate and the accuracy is solely dependent on the information provided by the experienced estimator on productivity rates. Three elements are vital to an accurate estimate:

1. Determination of the quantity of work
2. Identification of the productivity needed to perform the work
3. Calculation of the unit cost of the resources to be used for the work.

Of these three productivity is the element most subject to uncertainty. Given the wide variation in the productivity of the resources that are part of the construction production process,

the forecasting or estimating of productivity is undoubtedly the leading risk factor in a construction estimate. The estimators get their information for productivity rates from numerous sources which includes field experience, books, and historical records.

Productivity of construction producing resources to include labor and equipment is dependent on numerous factors, including weather, workers morale, and supervision. These are only a few of the factors the estimator has to deal with. It is the estimator's ability to identify the many factors that impact productivity that in great part dictates the accuracy of a construction estimate. Clearly the estimators understanding of productivity including its forecasting and measuring enhances a contractor's ability to improve his performance. With the more standardized productivity information available to the estimator the less time he spends preparing the estimates and the less money involved in the preparation phase. We can never realistically expect the estimates to be 100% accurate, however, the degree of accuracy goes up with the amount of productivity information available. The lack of estimating-accounting sophistication often contributes significantly to the residential contractor's high failure rate [Adrian, 1982]. The failure rate in 1984 for the construction industry in general was 112 per every 10,000 contractors. The reason most stated was poor management which includes the lack of proper estimating and accounting [Milner, 1987].

COST ACCOUNTING

The cost accounting system of every organization and every project plays a great role in measuring and determining productivity and consequently estimating the next job. Not to mention providing the Construction manager with proper controls to monitor the job he is working on now. All the systems that it takes to construct a project are interrelated and when one suffers they all suffer. Although cost accounting is not the subject of this paper it is important to emphasis the importance of a accurate, timely, and detailed cost accounting system. The level of effort must be dependent, of course, on what you expect to get back in return. Good project control and accurate information for future estimating. As Mr. Sherman from Bechtel stated "the accuracy of the project cost accounting system depends upon those guys filling them out correctly and not cheating". The cheating he refers to comes from a lack of understanding by the field personnel as to the intended use of the information. If they were using the accounting system as a hammer to hold over the heads of the field supervisors we will never get the accuracy we need. We really do not need to use the accounting system in that manner since there are so many other ways to check the performance of a crew without the direct threat of the accounting system. Finally the capabilities of labor are not always being measured. What is determined is the effectiveness of the system in converting manhours efforts into useful products.

Insight gained from the interviews and from personal

experience shows most companies are using manhours in the denominator for several reasons. The basis for most companies measuring their productivity using man-hours is very simple, first the quantity of labor required is more susceptible to the influence of construction management than are quantities of either capital or materials. Secondly labor constitutes such a large part of the cost of construction. The construction productivity measuring methods vary from company to company and often within a single company from project to project.

MEASUREMENT TECHNIQUES

There are two basic approaches to measuring productivity: single factor and multifactor measures. Single factor measures use only one input in the denominator. The most commonly used measure of productivity is labor productivity as mentioned early. In construction, square footage and dollar value put in place per hour are commonly used indicators of labor productivity. In certain situations, other single factor measures might also be useful, such as capital productivity (the ratio of output to capital input) or land productivity (the ratio of output to land use).

When using any of these single factor measures we must be careful to avoid assigning causation of productivity change to whatever input happens to be in the denominator. Increases in labor productivity does not necessarily indicate that workers are becoming more skilled or putting out more effort. Higher labor productivity can also result from increases in the quantities of other inputs, especially capital, or changes in technology or

organization. In fact, it is possible for labor productivity to increase while capital or land productivity decreases. It is very difficult to determine what has actually happened sometimes. Because the single factor productivity measure is difficult to interpret, the multifactor approach was developed.

Multifactor productivity measures use a weighted average of all inputs in the denominator. The weights usually correspond to each input's share of total expenditures. Multifactor measures reflect the joint impact of all inputs on productivity more accurately than single factor measures because the quantities of all inputs are in effect held constant. The problem with this is one cannot identify the single factor that is contributing to the increase of productivity to apply it to other projects and jobs. So in the first case one can mistake a increase in productivity and give credit to the wrong resource and in the other case one cannot identify which resource to give credit to at all.

The scope of productivity measurement is very large. This paper is going to focus in on the microlevel productivity measurements used by construction managers to control construction projects and to estimate future ones, rather than macrolevel measurements with multifactor denominators.

Before discussing the measuring techniques the paper will quickly review what has been covered so far and review the steps necessary to start our site productivity measuring system:

Step 1. Setting up the cost accounts in enough detail so that it provides the level of detail necessary to evaluate

the productivity.

Step 2. Determine the quantity of work to be done.

Step 3. Establishing the budget for each account.

Step 4. Measuring the work as it is completed.

HISTORICAL

The first measuring technique which deserves our attention is really a function of good accounting and a by-product of projects completed. However, it is still a method of measuring and comparing productivity on a current project. Historical measurements of productivity can be invaluable if used and stored correctly. The old excuse about every project is unique and therefore one cannot use old data from past projects is nothing more than an excuse for bad accounting practices. Sure every project has its unique features but the estimators and construction managers can apply the productivity rate developed through the company and manipulate them quickly to fit the project. This approach is much quicker and cheaper than starting from ground zero or using a commercially published list of productivity rates. Some of the best and largest of the commercially published references are:

1. Dodge Construction Pricing and Scheduling Manual
2. R.S.Means Building Construction Cost Data
3. F.R. Walker's The Building Estimator's Reference Book
4. The Richardson General Construction Estimating Standards
5. National Construction Estimator

However, it must be kept in mind that R.S. Means and the others

do not sit down and develop fool proof productivity rates. They accumulate the construction data that is supplied through their contacts in the industry and manipulate it into area averages [Halpin, 1980]. The estimating references contain listings of cost per line item similar to the cost account line item a contractor would keep. As discussed during a phone conversation between the author and the R.S. Means office in Duxsbury Massachusetts, the values published by this references are not scientifically proven nor are they statistically based. They are a good starting point if one does not have a company historical record to base your estimate on. The information accumulated in historical records must be widely distributed and usefully correlated so the estimators and construction managers can use them. Once again this is a function of good and accurate cost accounting procedures.

SCIENTIFIC

Another measuring technique which once again is used for setting standards or goals and used for estimating productivity with a great efficiency is the Scientific based productivity standards or Statistical Standards. Included in this section is the Work Study Method, Methods Time Measurement (MTM), and Method Productivity Delay Model (MPDM). The techniques reviewed in this section are used primarily for setting standards also called engineering standards.

For the work study method a knowledge of basic probability statistics is very useful since much of the data collected is subject to variability and cannot be determined with absolute

certainty. Also it is impractical to observe all workers relevant to study, nor is it always practical to observe the workers continuously. When conducting a work study it is paramount to kept the contractor's needs at the top of the list. The work study design needs to be flexible enough for the observer to respond to changing conditions on the job site. The work study procedure should adhere to the following basic steps in a flexible set up.

1. Select the work to be studied and do not vary
2. Record all relevant facts
3. Examine the facts critically
4. Develop the new method
5. Install as standard practice the new methods
6. Maintain by routine checks

The specific details of work study is very similar to work sampling and most of the procedures used are the same, however, the work sampling is of more interest to this paper and is covered in detail in the Performance Evaluation Techniques Section later in this chapter.

The MTM system is based on the concept that methods determination preestablishes the time determination with factors available to take into account the crews experience, weather at the site, and general site conditions. The experience of the estimator must of course assign values to this adjustment factors as we will see. Once the method of construction is determined, a time can be very accurately compiled from the times needed for the elemental operations. Each Project is broken down into

construction activities and each construction activity is broken down even further. The MTM system has already done the time studies on the time it takes to turn, to pick up a block, to nail a stud in place and ect.. Each turn and grasp studied was then broken down into as many as 18 different movements. For each there is an elemental time measured in TMU (time measurement units); 1 TMU =0.00001 hour = 0.0006 minute = 0.036 second. The MTM time studies are then put back together to form construction times for laying a block on the ground using one labor and one mason or for no labors and one mason, or for any combination and experience level you factor in. For example this is taken from reference [NAVFAC, 1983]:

Table 4-116. Install Concrete Pipe

WORK ELEMENT	UNIT	MAN-HOURS PER UNIT
12" diameter	100 Lin Ft	20
18" diameter	100 Lin Ft	34
24" diameter	100 Lin Ft	46

SUGGESTED CREW SIZE four to eight UT's
NOTES: LIfting equipment required for all sizes of concrete pipe.
2. Man-hours estimates for manholes or catch basins based on making tie into existing manholes or catch basins.
3. Types of cement pipe joins; concrete, oakum, mortar and speed seal.

The most complete studies of the MTM was done by the United States Navy in the late 1950's and updated every couple of years since [NAVFAC, 1983]. The MTM estimating books are very useful and easy, however, their accuracy depends greatly on the experience level of the estimator using it. The advantage to the MTM estimating book is that the productivity rates are given from

years of scientific experiments and experience. When using the MTM you never have to start from scratch, you have the time estimates for your basic work elements and you can go from there. The accuracy of using the MTM as you can see is directly proportional to your estimator's experience level.

The Method Productivity Delay Model (MPDM) was developed by James J. Adrian [Adrian, 1982]. It is basically an alternative to the more traditional time study model of helping the construction firm predict, measure and improve productivity. Like the time study model it requires extensive field observations to review the current operations and hopefully set engineering standards for the current and future projects.

The MPDM system has four elements, the collection of data, the processing of data, structuring a model of the operation, and the implementation of the desired changes. The collection of the data involves four events:

1. Time required to complete production cycle.
2. Occurrence of productivity delay.
3. Total cycle delay allocated by approximate percentage or by documented times, if more than one productivity delay type is found in a given cycle.
4. Any unusual events that characterize a given production cycle.

The data sampling techniques are provided by Adrian on his own data collection forms. He takes in account five different types of delay:

1. ENVIRONMENT

2. EQUIPMENT
3. LABOR
4. MATERIAL
5. MANAGEMENT

These are the normal delay elements associated with most model techniques. He provides the connection between the collected data and the structured element by processing the elements of the system. He develops his calculated delay factors and idealizes productivity rates and predicts the new actual productivity rates. The implementation phase now happens and with continued monitoring we develop and document the results. The idea behind this is to increase the productivity on the documented project and develop some engineering standards for the future.

MEASUREMENT OF OUTPUT

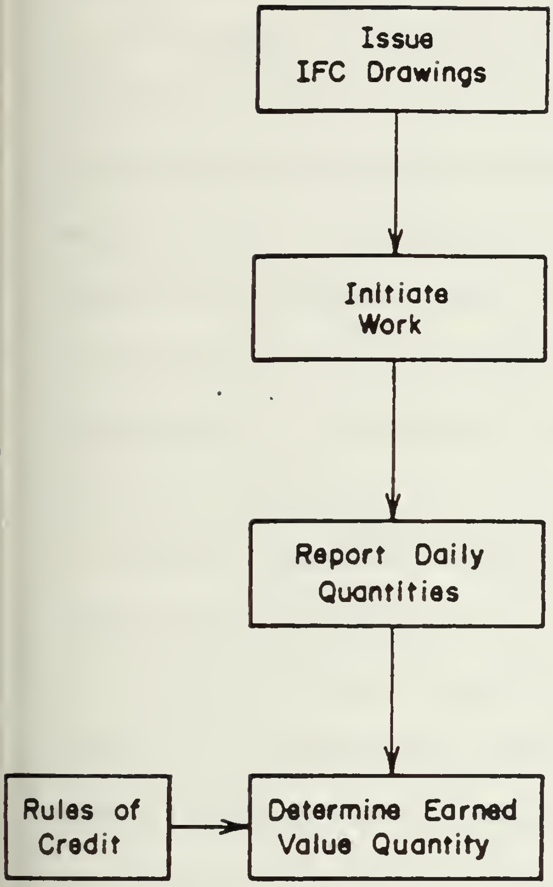
Productivity in the construction industry in its generic form is simply defined as OUTPUT/INPUT. Some construction companies prefer the terms reversed so its INPUT/OUTPUT which is not unreasonable. However, one is back to the same problem of determining how to measure the input and output. The methods above show methods for determining engineering standards of productivity and methods for field observation, but do not implement systemic checks that would normally be desired. Just as there is no single best definition for productivity nor is there a single best method for measuring productivity. The best we can hope for now is industry standards and consistency. The first part of the productivity equation we will examine is the measuring of the output. Before we describe some techniques for

measuring output we need to clearly define what has already been eluded to several times, work activities. The work activities are broken down into the Work Breadkdown Structure (WBS) and the associated cost accounting charts are established. The primary purpose of the WBS and Cost accounts when used for productivity purposes is in determinations of the number of work units and later in collecting and reporting productivity data. Remember the estimator established these accounts and quantities from his estimation.

EARNED VALUE

The first method of measuring the OUTPUT side of the productivity equation is the EARNED VALUE METHOD. The earned Value is a project control technique which compares actual accomplishment of scheduled work and associated cost against an integrated schedule and budget plan. The earned value method uses an "intermediate milestone" concept in which a work package is subdivided into discrete activities. When each activity is accomplished, a portion of the estimated quantity is "earned" or given credit in reporting production output, based upon the rules of the credit weighing scheme.

The typical activities involved in measuring output using the earned value method is shown in figure 3. The field measuring process starts, of course, after the construction drawings are issued to the work force. After the work has started, the foreman reports the quantity of work-in-place using a daily quantity report which is part of the cost accounting system. Subsequently, the data from the daily quantity reports



Issued for Construction (IFC) Drawings are issued to the field construction work force.

Work associated with the IFC Drawings is initiated.

Foreman reports the quantities installed using the daily quantity in place report.

The Earned Value Quantity is calculated based upon the Rules of Credit and the daily quantity in place reports.

Figure- 3 Earned Value method of measuring output.

are entered into the reporting system. Then using the rules of credit and associated credit percentages the earned value of the output is calculated.

The daily quantity report is nothing fancy (unless more detail is required) it requires the foreman to identify the work by drawing number and location, description of work and the amount done. The cost account number should have already been supplied or added later. Many organization require the foreman to place the account number on the quantity work sheet, but from experience of the author and the interviews conducted this seems to be a draw back to the system. It opens the door to mistakes in account numbers assigned and for inaccuracys rather intentional or not.

Once the daily quantity reports are received by the cost accounting department the work of comparisons begins. With the advent of the micro computer this has been a much easier task. Using the summation of the daily reports the Actual Cost of Work Performed (ACWP) is determined, which is then compared to the original Budgeted Cost of Work Performed (BCWP). The comparison provides the cost variance percentage:

$$\text{COST VARIANCE } (\%) = (\text{BCWP} - \text{ACWP}) / \text{BCWP}$$

Of course, this is only one of the many aspects of the earned value system the construction manager is interested in. Some of the other aspects of interest are available after the establishment of the rules of credit and the definition of the following terms:

BCWS = BUDGETED COST OF WORK SCHEDULED

CPI = COST PERFORMANCE INDEX

The Rules of Credit is a distinct feature of the earned value method of measuring output. It is used to determine the "earned" value of the output. The rules provide a simple but structured method of allowing credit for partial completion of work packages. Each firm has its own set of rules. The rules of credit are especially important to the owner and contractor when the payment schedule is based on the amount of work completed in each period. Careful evaluation and agreement on the rules of credit must be completed during the contract phase of the project.

The other major equations of interest are:

$$\text{SCHEDULE VARIANCE (\%)} = (\text{BCWP}-\text{BCWS})/\text{BCWS}$$

$$\& \quad \text{CPI} = \text{BCWP}/\text{ACWP}$$

A $\text{CPI}>1$ means that the work represented is under budget, while a $\text{CPI}<1$ indicates the work is over budget.

The earned value method is flexible enough to let the work elements being monitored to be as detailed as required. Keeping in mind the purpose of monitoring the work in detail is because you expect the returns to exceed the cost. The CPI and other indicators that can be developed but not reviewed in this paper provide a very broad view of the project productivity. If any problems develop, further investigation would be required.

The flexibility of the earned value technique encourages management by exception. Variance thresholds may be established which identify those variances that require formal and detailed analysis and implementation of corrective action when exceeded.

As work progresses, management may adjust reporting requirements and focus on emerging critical areas in the WBS. Work elements of less concern may dropped or reported on less often. The earned value system is a great warning alarm for productivity problems [McConnell, 1985].

ESTIMATED PERCENT

The second method of productivity output measurement is the Estimated Percent Complete Method. The estimated percent complete is a commonly used method of measuring output primarily because it is the easiest and consequently the least expensive method.

The method starts out the same as most measuring techniques with the (WBS) and cost account charts. The primary purpose of both is to provide a structure for quantifying the number of units which is done by the estimator again and later collecting and reporting productivity data. As with the other methods the number of work units estimated is hopefully very accurate which provides us with a starting place for monitoring productivity.

Upon commencement of the work, a periodic evaluation of the percent complete of each account must be made. This evaluation may be performed by anyone familiar with the work. Obviously the accuracy of the estimated percent complete depends entirely upon the person making the evaluation. Ideally we use the opinion of a qualified expert whose expertise is in the area we are measuring [Parker, 1972]. Often, however, the project or craft superintendent evaluates the percent complete for each account in his responsible area. Obviously, care must be taken to ensure

that the percent complete assigned to each account is an objective evaluation, since the individual doing the evaluation may have a vested interests in the productivity numbers generated. This is especially true on the project level when the owner is paying by the percent complete of the project, and may be true on the lower level if the crew is getting paid bonuses for the amount of work performed during any given period.

This procedure is clearly subjective and the accuracy of the result depends upon the individual's ability and responsibility to judge the amount of work done. As a result of this, the adequacy of this method of output measurement for control purposes is questionable unless the quantities and assessment of completion status can be clearly defined. Projects such as paving are suitable for the percent complete method.

Another problem with the percent complete method is that the percent complete on a given project does not necessarily reflect the amount of effort expanded. Most estimates of man-hours to output are assumed to be linear, as we all know this is usually not the case. This assumption is made for the ease of estimation and scheduling. This distortion throws the productivity estimation and monitoring way out of line on a daily monitoring basis. For example, if you're constructing an underground water line you may excavated three hundred feet of line and had expanded 50% of the estimated man hours but have only laid 10% of the pipe and only are given credit for 10% completion. To change your construction method to lay the pipe as you go could be less efficient, however, you would get paid quicker increasing your on

hand momentary assets.

The primary advantages of the estimated percent complete method of measuring output, as pointed out by Mr. Sherman and Mr. McNair, is its simplicity and the relatively small effort or manpower required to implement it. Because of its low cost it tends to be used more on smaller projects and projects that are not complex and relatively straight forward like paving or block laying and require low overhead expenses.

Using the percent complete method on more complex projects leads to distinct problems with evaluating the percent of the work activities completed and establishing productivity rates in a timely manner for the construction manager to use during the life span of the current project. The problems encountered with evaluating the percent of the work activity completed arise from relying exclusively upon an individual's ability to evaluate accurately the work that has been done physically compared with the efforts expended. The percent complete method does not allow much flexibility for the common day change order which changes the quantities and scope of the project. Unfortunately, the easiest and cheapest method of measuring output is the most prone to error in the construction industry.

PHYSICAL MEASUREMENT

The third method of measuring productivity output is the physical measurement technique. This method actually counts or measures the number or amount of units of work completed or in place. For example the number of yards of concrete actually in place, or the number of cable trays placed.

To use this method of measuring effectively, the following criteria must be met:

1. The work task must be detailed and well defined
2. The work task must consist of bulk quantity items. The work must be broken up into small unique work packages.

Work tasks should consist of exclusively bulk quantity items to facilitate measurement of work units completed. (output) Because of the usual mix of work elements and materials required in a project this method is almost never used. It is not practical to measure the items that need to be measured. The physical measurement method is only of use in fabrication shops which are designed to mass produce bulk quantity items. Combining this productivity measurement system with others on a very large project and combining them all in weighed multifactor productivity rates would be very useful.

The three primary advantages of the physical measurement method of measuring output is that it is the most detailed, and is; therefore, reliable for both future estimating and project control purposes. It is relatively objective and does not require the subjective opinion of the estimated percent method. The third advantage of this method is that an audit of the reported production output is easily accommodated. The primary problem with the physical measurement method is the cost of data collection and its limited use on construction projects.

MEASUREMENT OF INPUT

The paper has now defined the output side of the construction productivity equation, and has shown several methods

to systematically keep track of the output units. Now the paper focuses our attention on the input side of the equation.

Input involves the tracking of the costs and man-hours associated with work produced. It may be classified into direct work and indirect work accounts. The method of determining how the input is classified may have a significant effect upon the measured input value. The most common definition of direct labor is labor which directly contributes to placing material in place, such as installing windows. Indirect work is commonly defined as the work or effort required to support the direct labor. An example would be delivery of the windows to the job site. The major difference between the two is the direct work is used in determining the measured input value and used for the determination of the productivity rate. The indirect labor is maintained and classified in another account and is not normally included in determining the input value associated with the calculated unit productivity rate. Clearly the classification scheme can be different for each contractor and is a function of the code of accounts and the Work Breakdown Structure developed before the project started.

The two methods of input accounting that we will investigate is the Man-hours method and the Dollar method. The obvious difference is the unit of measurement. Both are commonly used throughout the construction industry. All the interviewed companies used this method.

MAN-HOUR METHOD

The Man-hour method of measuring input is the most commonly

used method in the construction industry. Figure 4 shows a very simple flow chart of the method. The man-hour method requires the foreman to assign, on a daily basis, the number of hours each craftsman worked on the individual work element. Some companies actually require the foreman to assign the appropriate cost accounts using the project cost account charts. Some companies have gotten away from having the foreman assign the cost account numbers and only require them to write a brief description of what they did. The assumption is the cost engineer people are following the project closely enough so they know what area of the project is being worked on just by reading the description or visiting the work area. The method of having the cost engineers assigning the cost account numbers hopefully avoids the mistakes made assigning man-hours to indirect accounts and to the padding of some work element accounts. If one mistakenly assigns man-hours to the indirect accounts you deflate the productivity rates of that work element. This not only affects the current project but also the projects to follow if your using your historical data to estimate projects. The foreman likes this method because they no longer have to know the cost account numbers.

An important activity in the input measurement system is a review or audit of the daily timesheet generated by the foreman. This review is performed by the cost engineer and the superintendent and is done to ensure proper coding of the daily timesheets in accordance with the project cost account charts. It is obvious that the validity of the entire productivity measurement system is predicated upon the assignment of man-hours

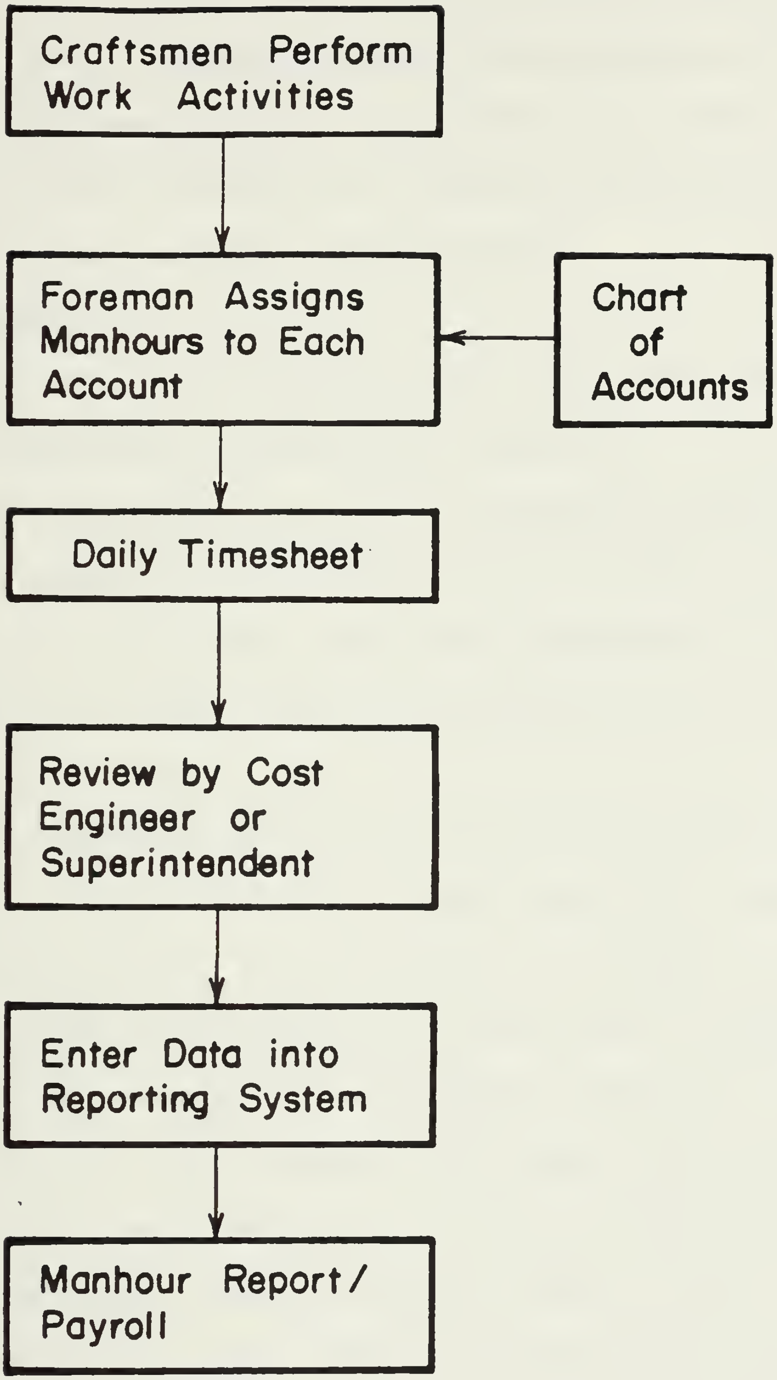

Craftsmen Perform Work Activities
Foreman Assigns Manhours to Each Account
Chart of Accounts
Daily Timesheet
Review by Cost Engineer or Superintendent
Enter Data into Reporting System
Manhour Report/ Payroll

Figure 4 Manhour method of measuring input.

to the correct cost account code. Many a superintendent has pulled out his hair trying to get the cost accounts straight once they have been improperly kept. There never will be a proper representation of the productivity rate performed by the laborers if they are not kept accurate from the start.

DOLLAR METHOD

The Dollar method of measuring input is not widely used except in the commercial construction industry.

The dollar method begins exactly the same as the man-hours method, the difference being that the dollar method includes wage rates in measuring the input. The method assigns a dollar value which represents all labor costs associated with an individual cost account.

The most significant feature of the dollar method is that two variables, man-hours and wage rates, are used in determining the input associated with a given output. A change in the composite wage rate or crew mix may significantly affect the value of the input. For example consider a crew of 4 labors moving masonry block. They worked four hours moving blocks, at $7.00/hr each. It cost the project $112.00 to move the block. Now suppose a mason was helping and now there are only three labors. The labors are still getting $7.00/hr but the mason is getting $12.00/hr. It now cost $132.00 to move the same stack of block.

A comparative analysis of the man-hours vs. dollar methods of measuring the input reveals that the primary difference between the two methods is that the man-hours method focuses

strictly on the number of man-hours required to achieve a corresponding output, whereas the dollar method takes into account the economic effect of wage rates and various crew mixes might have upon the input value. It may be more difficult to compare different projects using the dollar method. It is also hard to compare the same project using the two different methods. The project was built for a given amount of money, yet depending on which productivity measuring system you use (remember you have any combination of denominator and numerator) you could have numerous different productivity rates for the same project and the same crew. Now take into account the concept of direct and indirect work and its classification and its various forms between contractors, owners, and specialty contractors. The problem of standardized productivity rates even for a single company becomes extremely clear without taking anything else into account.

PERFORMANCE EVALUATION TECHNIQUES

There are two primary purposes for measuring productivity: First, to provide the construction manager the information required for controlling the project schedule and cost. Second, to provide the company and the estimators with the information and data required for estimating future projects. Performance factors are a measurement of the productivity of the construction effort as compared to the estimated effort and the budget. Performance factors merit discussion because of their considerable power to aid in controlling the project.

Performance evaluation techniques can be categorized as

performance factors and input utilization techniques. Considerable attention is given to performance evaluation techniques, particularly performance factors, by the construction industry because they are a very useful tool for controlling both project costs and schedules. The popularity of the input utilization technique such as work sampling, foremen delay surveys, etc.) are increasing due largely because of the support given them by the CICE and CII [Summary, 1983]. Utilization techniques are not used on a larger regular basis from the information I was able to obtain through interviews and research.

PERFORMANCE FACTORS

Performance factors can be defined in many ways. In order to simplify comprehension and explanation of performance factors, the following assumption is made: The unit of measuring input is man-hours. Based upon this assumption, a performance factor may be defined by either of two methods. The most commonly used in the construction industry, defines a performance factor as the number of earned man-hours divided by the number of actual man-hours associated with a particular cost account. This is what makes performance factors so easy, because the information required to develop them is already on hand if any cost accounting system is being used. The number of earned man-hours is calculated by multiplying the earned quantity, described earlier in the paper times the estimated or budgeted unit man-hours productivity rate.

PERFORMANCE FACTOR

$$(\text{EARNED QUANTITY INSTALLED}) \times \frac{\text{ESTIMATED UNIT MAN-HOURS RATE}}{\text{ACTUAL MAN-HOURS}}$$

The actual man-hours represent the input associated with the quantity of work-in-place. The second method of describing a performance factor is defined as the estimated or budgeted unit man-hours rate times the actual quantities installed, divided by the actual man-hours associated with the work.

PERFORMANCE FACTOR

$$(\text{WORK QUANTITY INSTALLED}) \times \frac{\text{ESTIMATED UNIT MAN-HOURS RATE}}{\text{ACTUAL MAN-HOURS}}$$

The difference between the two measurements is that the former uses the calculated earned quantity and the latter relies upon the actual quantities installed.

The first method of determining the performance factor is most commonly used in the construction industry. The primary use of performance factors is for project control and forecasting. We have shown earlier how to develop the output and input side of the equations. We have also talked about developing engineering standards of productivity, referring to the estimated unit man-hours rate term in the equation. It is important to stress that an accurate estimate of the budgets productivity rates for each account should be made for the reason of USEFULNESS. The performance factor is useless if the productivity rate that one is basing the comparison on is inaccurate.

The performance factors are most efficient when tracked over short periods of time and are maintained cumulatively to average out any high or low rates. This allows the construction manager to monitor both short term and long term productivity. The

periodic performance factor provides a measurement of short term productivity or the latest reporting period exclusively, and is used primarily for immediate project control purposes. For example, a large drop from one reporting period to the next reflects a significant reduction in productivity, which should cause construction management to investigate what circumstances may have caused the reduction in productivity and what corrective action may be required. The cumulative performance factor provides a measurement of long term productivity and is used not only for long term project control but also for trending and forecasting purposes. Based upon historical data from previous projects, an expected cumulative performance factor profile can be developed from which we can, with reasonable accuracy which allows us to compare previous projects to the existing projects. The predicted value allows the construction manager the ability to evaluate the expected productivity and expected overall cost of the project.

INPUT UTILIZATION

The input utilization techniques are gaining popularity within the construction industry and some have been used for a long time with varying degrees of success. Input utilization techniques, as an indicator of productivity, evaluate only the utilization of the input resources and the effecient use of the input resources but do not consider the corresponding output. The principal input utilization techniques are:

1. Work sampling
2. Five minute method

3. Field ratings
4. Foreman delay surveys
5. Stop watch ratings
6. Film analysis

Work sampling is an activity measurement technique that determines the percentage of time that the labor force spends in predetermined categories of activity. Work sampling is a statistical sampling procedure that requires collecting a large number of random samples or observations of the activities of the craftsmen or equipment. Normally, a large number of random samples are a small percentage of the total project activity. In planning the number of random samples to be taken, you must set the confidence level desired. For example, in planning for an absolute limit of error, Sn, of plus or minus 4%, at a specified 95% confidence level. The number of observations required, n, is:

$$n = \frac{K^2 P(1-P)}{Sn^2}$$

When an observation is made, the activity is classified into predetermined categories of activities that have been selected because of their pertinence to the nature of the work [Thomas, 1983]. From the proportion of observations in each category, inferences are made regarding the total work activity. The biggest advantage is that you can have your evaluation of effectiveness in minutes, or hours, rather than days or weeks. The reaction time of the construction manager is greatly increased.

A work sampling study can be tailored to fit a variety of different objectives. The need for objectives are paramount to the success of any analysis. To obtain good results some other general rules for work sampling must be observed in sampling construction workers.

1. Every workman must have the same chance of being observed at any time.
2. Observations must have no sequential relationship.
3. To preclude any bias, the rating must be made at the instant each man is first seen; the observer must not rationalize on what tasks the workmen have just finished or what they are about to do next.
4. The basic characteristics of the work situation must remain the same while the observations are being made; likewise, comparisons among sets of observations are valid only if the work situation is substantially the same.

The last rule seems difficult to achieve, however, most trained observers can observe their subject 85 to 95 % of the time before they are seen [Parker, 1972]. The analysis of the sampling is done by a professional and put into a table or graph like the one in figure 5. Work sampling is a useful tool to measure the productivity activity of one's labor crews with very quick results for the construction manager. The disadvantages being they are often thought of as an audit. This results in defensive attitudes, criticisms, and resistance, all of which harm the effectiveness of the study. The next problem with work sampling being that it cannot differentiate between productive work being

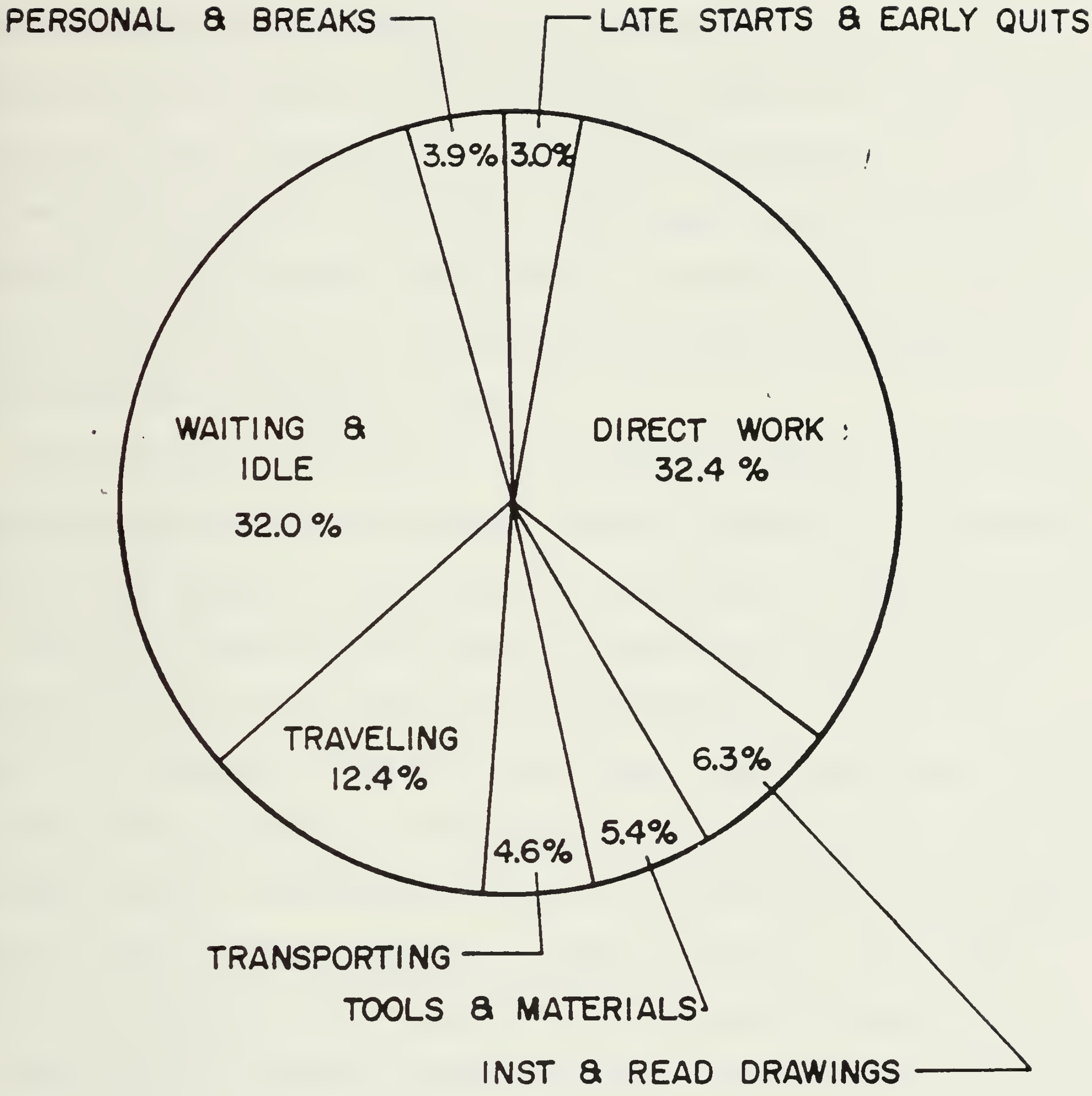

PERSONAL & BREAKS
LATE STARTS & EARLY QUITS
3.9%
3.0%
WAITING & IDLE
32.0 %
DIRECT WORK
32.4 %
TRAVELING
12.4%
4.6%
5.4%
6.3%
TRANSPORTING
TOOLS & MATERIALS
INST & READ DRAWINGS

FIGURE 5.

done and unproductive work being done. The work sampling technique is subject to observer bias and variations by different observers on the same project or a different project. Mr.Sherman discussed the results of a work sampling analysis on his project, and found it did not help the construction manager at all and only made the project team mad. The results were not clearly presented to the project staff before release to the company headquarters; therefore, the project team felt the measuring techniques were seriously flawed.

Nevertheless, successful work sampling programs have been implemented where there has been careful attention to the details of how the program was executed and presented to those involved.

Several types of Work Sampling techniques are in use and they vary only in the degree of sophistication. One of the simpler techniques is the Field Ratings. This technique requires only that the activity of the workers be classified at the moment of observation. Two classifications are generally used; namely, "working" and "not working" in a useful activity. The basic rules for a simple field rating method are as follows:

1. Mechanical counters should be used. One records the working laborers and the other records the total laborers.
2. The count should cover all laborers. When greater detail is desired, counts should be reported by crafts, area, and crew.
3. The person making the count should devote his total attention to the count while it is being made.
4. The rating should be taken at the first instant of

observation.

5. The person doing the counting must understand the reasons for making the count and should be trained in correct procedures.
6. To record normal activity for a project crew, counts should not begin until at least half an hour into the work day.
7. No counts should be discarded.

To qualify as "working," laborers should be engaged in such activities as:

1. Carrying material or holding or supporting material.
2. Participating in active physical work, including measuring, lay out, reading blueprints, writing orders, etc....
3. Providing directions to other laborers.

Activities such as the following would be listed as "not working".

1. Waiting for another to finish work, waiting for a tool, or waiting for instructions.
2. Talking, sipping coffee, etc...
3. Driving aimlessly in the company truck, or riding in the back of a truck driving aimlessly.

A single field rating is merely an indication of possible problems and no single rating is a conclusion. The crews will learn very quickly who is doing the counting if it is always the same person or the same truck driving slowly around the site. If you have special color hard hats for management the laborers will see you a mile away if they are not working. The count will be flawed if not thought out before hand. If the crews are working

they will not notice management approaching because they are too busy to worry about it. However, the fact that the laborers know management is interested in the productivity of the individual labors will be worth more than if management showed no interest at all [Drewin, 1982].

The five minute rating technique is even quicker and less exact than the field rating method; even so, it is an effective method for making a general work evaluation. The five minute rating technique is based on the summation of the observations usually too small to offer the statistical reliability of work sampling.The purpose of the five minute rating technique is:

1. To create awareness on the part of management of delay in a job and to indicate its order of magnitude.
2. To measure the effectiveness of a crew.
3. To indicate where thorough, detailed planning could result in further savings.

The five minute rating counts two types of delays:

1. Delays that impede the progress of the job.
2. Delays that do not affect the progress of the job but only the cost of the job.

To make a five minute rating, the observer must place himself in a position from which he can observe the whole crew without being conspicuous. In this way, the men will not be aware of who is being observed and will not react to his presence. For small crews working in close proximity to each other, all are observed at the same time. Large crews can be mentally divided into subgroups for ease of observation. Each groups is then observed

for a period of from 30 seconds to several minutes, and the ratio of delay, or nonwork, to total observed time is noted. If the delay exceeds 50 % of the period of observation, then the block of time for each man so observed is classified as a delay. If the delay does not exceed 50% it is classified as effective. The five minute rating is named this because as a rule of thumb no crew should be observed for less then five minutes.

An adequate knowledge of crew effectiveness is usually achieved by making four separate five minute ratings in a day, two in the morning and two in the afternoon. An experienced observer learns to judge whether longer or additional studies will affect ratings made in minimum recommended times.

The real goal of the five minute rating technique is to have a qualified, trained observer watch the crews and measure their productivity without the crews knowing they are being observed. The benefits are professional opinions on the effectiveness of the labor input: meaning the direct time of work to nonwork. Because a crew is busy does not mean it is productive. The five minute rating can give the construction manager additional information and possible insight as to the laborers work habits from another professionals opinion [Drewin, 1982 and Thomas, 1983].

The most recently developed tool for obtaining information about input utilization is the Foreman Delay Surveys (FDS). The basic premise of the FDS approach is that the foremen, who are closest to the work, can best identify and estimate time losses at the end of each day. Other types of studies have shown that

major sources of construction inefficiencies are the delays from lack of materials, tool information, etc, which are often outside the foremen's control [Rogge, 1982 and Tucker, 1982]. Thus the FDS is a simple method of measuring the influence of administrative actions or activities that are external to a foremen's control, but at the same time, have a strong influence on the crew's performance.

The prominent features of the foreman delay surveys are:

1. They provide current estimates. Information is reported at the end of each day.
2. They can canvass an entire project, rather than just a sample of the work force.
3. They are inexpensive and easy to administer since only five minutes of a foreman's time is needed to complete the form each day.
4. They provide information on specific items of delay, such as:
    a. Materials
    b. Equipment
    c. Tools
    d. Information or direction
    e. QC inspections
    f. Other crew interference
    g. Waiting for transportation
5. They identify delay difficulties by craft and crew, enabling management to direct attention toward crafts that need assistance.
6. They provide a mechanism for two-way communications between project management and foremen. Follow-up meetings to discuss survey results permit discussion of identified

problem areas and possible solutions.
The delay form usually covers nine categories with a tenth one for "other" to be identified by the foreman. They are similar to the average work sampling categories. Of course, the categories can be changed to fit the individual projects needs.

Foreman delay surveys are easy to administer; but, like all things on a construction site, they just don't happen. The foreman must have a clear understanding of what the construction manager's expectations are. All the foremen must know that the FDS program has full management support. Accuracy must be emphasized each day. We should limit the time period of each survey to no more than one week per month or the effect of the surveys will gradually be minimized. The survey will become just another useless report for the home office. The foreman must have a clear understanding of probable benefits to himself. He has the most to gain in the short run. They must understand that the FDS program is not an evaluation of their performance but a way to remove roadblocks to their effectiveness. The FDS must be made simple and easy to follow. The results must be published and acted upon and no one should be allowed to slip a few days with their report submission.

The FDS is implemented through a five step program:
First, foreman orientation; this fifteen minute to an hour meeting lays the ground work for a successful program. Enough meetings should be held to include all foremen in groups of thirty or less at a time. Topics to be discussed should include the potential benefits to foremen, management expectations, how

the survey works, review the form and timing and channels for its distribution and collection.

Second, collection of the reports; delay reports should be collected daily.

Third. delay report summary; reported delays and rework should be summarized by category and by craft.

Fourth, review the results; a meeting should be held with the foremen to review the summary of delays and rework as soon as it is available. Once again, enough meetings should be held to keep the groups of foremen small. The meeting is not a finger pointing session. This meeting is very important. It reassures the foremen that you have taken their delay reports and done something constructive with them. It provides an opportunity to obtain specifics about reported problem areas and a forum for discussing potential solutions. The motivational aspects of this meeting will be discussed later in Chapter Four.

Fifth, take visible positive action; a highly visible improvement in operations implemented by the construction manager as a result of foreman suggestions will do more than anything else to convince the foreman that the FDS program is worthwhile and that management will do its share to improve labor productivity.

The FDS programs implemented to date recommends monthly cycles of the FDS program, with the opening meeting being shorter than the first [Tucker, 1982].

The development of the foreman delay surveys grew out of the belief that helping the foremen and his crew do their jobs better is a very important key to improving construction efficiency.

Unlike the other techniques, it is accomplished without outsiders coming onto the job site daily and observing; therefore, the FDS program is less threatening to the work force. The FDS program is often run concurrently with other productivity measuring programs such as work sampling, with the help of the construction manager the obstacles identified by the FDS program can be moved from the foreman's path. This should reduce their inefficiency and also motivate them to work smarter. The FDS is not a substitute for crew level work sampling and time-lapse photography. These methods are still most useful for methods improvement studies [Rogge, 1982].

As mentioned early Frederick Taylor who did so much research in efficiency and thought that management could be an exact science is the father of time and motion studies. He felt if one can divide the work up into enough discrete, programmed pieces and then put the pieces back together in a truly optimum way, one would then have a truly top performing unit [Peters, 1982].

Stopwatch studies come from this basic idea. It is a detailed record of the current method that shows exactly how the work is being done. This may vary with how it is supposed to be done or how the job was planned.

The stopwatch study requires the minimum of equipment, but unfortunately its results are limited by the proficiency and training of the operator. This technique is the cheapest and fastest way to record a specified sequential event involving one or two men and/or a piece of equipment.

The limitations of stopwatch studies are numerous starting

with the precise description of the work activity that must be measured to the experience of the observer. The observer must decide instantly when one phase or cycle stops and another begins. When the construction activities are not clearly separated and cycles are irregular, in order and type, there can often be differences of opinion as to when one phase is completed and the next begins.

Another major factor that must always be considered in great detail and with gloved hands, is the reaction of the crews to stopwatch studies and for that matter time-lapse studies which will addressed in the next section. In the past, there has been strong reactions against managerial attempts to exploit the worker by using work improvement studies. This is indicated by the congressional prohibition against stopwatch studies of federal government employees in every budget appropriation from 1913 to 1949. The effort must be made to convince the laborers that the stopwatch study is not an evaluation of their individual productivity and should never be used as such.

A more significant error in stopwatch studies of larger groups of people and equipment is that one observer could have a hard timing watching and recording the activities of many people and equipment. If the cycles are exact and he is only measuring the complete cycle time than this is not a problem. For a general rule, however, it is inherently difficult for a single observer to accurately record any operation that involves many components. We either increase the number of observers or decrease the scope of the description of the work activities.

There are numerous other limitations and short comings to the stopwatch method of measuring construction productivity. In spite of its limitations, however, the stopwatch study is an extremely useful tool, especially in instances where only one or perhaps a few elements or components are to be observed.

The final input utilization technique we are interested in is the time-lapse motion pictures. This method has also been in use in the construction industry for some time. It is a very reliable method to measure the productivity of a labor crew over an extended period of time. It had been used by the majority of the Companies interviewed at some point in time.

Over a period of many years, the time-lapse camera has proved an excellent means of collecting information and data for work improvement studies. It can measure a large number of laborers and equipment at one time, able to record interrelationships among these components, and useful as a permanent, easily understandable record. It has also proved extremely valuable as a means by which foremen and other supervisory personnel can study and improve their jobs without resorting to the detailed formal work improvement techniques. The safety of the working techniques can be reviewed easily. An hours worth of work can be reviewed in two to four minutes depending upon the number of frames per minute selected.

The majority of the short comings of the time-lapse method have been eliminated with the advent of the Video Cameras. The expense has been greatly reduced. The past major disadvantage was the cost of the equipment and film development. Now days the

operator costs no more than any other trained observer used in the field. In fact, many of the motion picture machines available today will require no operator at all. The batteries required by the old cameras are now built into the new cameras with some having capacity up to six hours. The time lapse between taking the film and reviewing it which caused problems in the past are now gone. With the video camera you can review in the camera immediately following the shooting of the film. The interval settings of the past can be adjusted depending on your interest. The Video tapes today can shoot up to six hours per cassette. The zoom lens desired are built in along with a microphone. The level of technical knowledge required for photography is extremely simple with the new cameras. The technical problems of time lapse productivity method have be eliminated.

Some useful consideration for time-lapse studies are:

1. The purpose and objective of the study should be explained to the foremen and crew before the start. Without the cooperation, the observer will be unable to perform his job effectively.
2. The observer should be introduced to the workers by the foremen.
3. The camera location must be preplanned. The camera should be slightly higher than the work location. The view of the work site must be clear.
4. Selection of the study period should consider all the interruptions.

5. Time intervals between frames should be from one to three seconds depending on the level of detail desired.

6. Notes pertaining to activities outside the camera range can be recorded on the film by talking into the microphone.

7. It is helpful to record names, locations, times, film speeds, and all other relevant details on the film.

8. A continuous time record can be made by placing a large clock face in the viewing range of the camera, or by having the manufacturer place an internal clock in the video camera memory, of course at extra charge.

The use of time-lapse study has dropped considerably in the recent past partly because of the problems involved with the older camera equipment and the technical level required to do the photography. With today's video camera the time lapse studies will be more and more popular as the construction industry wakes up to their potential use [Drewin, 1982].

WHITE COLLAR PRODUCTIVITY MEASUREMENT TECHNIQUES

Very few studies has been done in the construction industry on the productivity of the "professionals" meaning the engineers, cost engineers, and construction managers. The American Productivity Center seems to be the leader in white collar productivity studies, seminars, and measuring techniques. Very few of the studies have involved the construction industry [APC, 1987].

Very little historical data is kept on man-hours spent on engineering projects. Most engineering estimates are made from the expert's experience with no real statistical back-up or

proven accuracy. The engineering managers and estimators rely almost completely on past personal experience. During the interview with Mr. Griffths, he explained that each engineering section is responsible for their estimates of man-hours required on individual projects. Estimates on some projects are very accurate and some are not.

COMMITMENT TECHNIQUE

One of the white collar performance methods found is used by the Tennessee Valley Authority (TVA). The reason that productivity measurement has been so difficult in the engineering office is because the primary output is information. Some of the more tangible outputs are drawings, procurement, and specifications, which do not truly reflect the total service rendered by engineering office. The input side of the productivity equation is the same as before with either a man-hours or dollar figure.

In most engineering firms it is far more important to measure the effectiveness and efficiency level that relates to performance than to concentrate on productivity. Many firms have found surrogate output measurements such as profit rates, quality, and customer satisfaction. Very few engineering companies have found a form on how to measure performance of the organization.

In 1984, TVA's office of engineering, started a performance measurement system that measured and developed a set of indices that gave trends of performance. The three trends used were:

1. Macro comparison with other A/E firm's rates

2. Internal rates in the office of engineering with past performance.
3. Project and client satisfaction.

Each trend had numerous indices for example. They developed a second set of performance indices such as actual expenditures versus budget, billing ratios and etc...

The overview of TVA's performance measurement system was a Commitment Management System. How well commitments made are being met. The commitment was considered met when all work previously agreed to by both the engineer and client was completed. If the client never complained or voiced an opinion, meaning silence constituted acceptance, then the commitment was met [Armentrout, 1986].

The program has received alot of higher management support and although parts of the system are overly simplified, it is an effective trend measure of professional productivity in an area that has always been hard to measure. Productivity management in an engineering firm or organization is possible although it is not feasible yet to measure it directly.

PERFORMANCE EVALUATION

The most commonly used productivity measurement of the construction managers is the professional evaluation by upper management. For many years efforts have been aimed at improving productivity of the laborers thru several approaches some of which have been supported by labor and some have not:

1. Substitution of equipment for human effort.
2. Improved methods of work.

3. Removal of unproductive practices.

4. Improved management of human resources.

Quietly these approaches have been applied to the professional staffs. We have introduced the labor saving computer for the professional, we have done study after study of improved work methods in the home office. We continually look for unproductive practices in the engineering profession which includes the field of construction managers. We work with the human resources available to improve their management techniques. Many of these efforts have been made through cooperating professional societies for engineering and construction, all in the effort of improving productivity. It has been hard enough trying to improve productivity of the labor in the field with different techniques, but professional staff improvements have been very hard. Everyone is familiar with the paper work reduction of several years ago, reduction of required meetings and casual visitors, and the two hour lunch breaks.

The majority of the engineering companies are trying to monitor their productivity through performance evaluations and reviews. The problems have been hard to deal with. Even simple things such as position descriptions have taken up numerous hours of time with no tangible measurable results. It does help the office organization, though, to have your duties clearly defined. The problem still exists that the performance improvement and productivity which increases within the engineering office, is hard and next to impossible to measure on any tangle scale except year end profits [Hancher, 1985].

One of the performance evaluation techniques usable in the office is the individual performance appraisal given each employee. The importance of this should never be glossed over. Even if only given one once a year, it deserves the proper attention and detail of the higher management in any organization.

CHAPTER THREE

INFLUENCES ON PRODUCTIVITY IN CONSTRUCTION

INTRODUCTION

In the past two chapters the paper has stated the importance of productivity on society, reviewed the various definitions and their relative applications, and have shown how it can be measured. Now the paper will investigate the various "external" influences on productivity in the construction industry.

There are the experts who feel an increase in productivity of the laborers can be achieved "through an endless stream of Hawthorne effects."[Peters, 1982] Hawthorne was a plant in Chicago where for five years social scientists experimented with worker productivity. The great observation made about the five year study was that the worker productivity increases were really based on the amount of attention given them and not so much the innovations developed to increase productivity. This was shown through increasing the light level for the safety and comfort of the workers which brought about an increase in their productivity. Several months later, the workers were told in great detail how the lighting was too bright for their own safety and comfort and the light level was dropped. Once again the level of productivity increased [Drewing, 1982].

The Hawthorne affect may be applicable in small control groups but not directly applicable to an industry. Especially an industry as fragmented and diverse as the construction industry. There are numerous "external" influences upon the productivity of the construction industry. When external is used, it is meant

not controllable by one construction manager or one laborer or one company. They are influences that are industry wide such as government regulation.

OPPORTUNITIES FOR IMPROVEMENTS

The opportunities for improvements in the construction industry are as great as they are varied. With so many sub specialties, hundreds of thousands of general contractors, and millions of workers, there should be many external ways to influence the productivity on the construction sites. Many of the cost saving ideas of improvement are simple yet still not properly used in the construction industry as a whole. A small sample of the ideas are listed below:

Constructability reviews
Use of more efficient equipment and tools
Contract modifications
Employee Effectiveness
Research and Development
Improved materials
Trained Labor force
Computer Simulation
Prefrabication
Robotics
Safety
Efficient government regulations
Production management
Marketing
Standardized Productivity measurements
Standardized Industry data and statistics
Equipment capability and capacity

The most interesting study done recently, which was conducted by Dr. McKee from the Chicago Institute of Productivity, was based on a survey sent to the largest 400 contractors according to the Engineering News Record. The survey was first conducted in 1979 and again in 1983. The return of the survey was a disappointing 25% in 1979 and 15% in 1983. The

results are fascinating and are at least representative of the construction industry attitudes. The surveys found the answers did vary greatly with the size of the company [Choromokos, 1981 and IITRI, 1987].

The universally agreed upon area for the most improvement in the 1979 survey was in the area of marketing. This is not surprising since this survey was taken during hard time in the construction industry when jobs were few. Several interesting articles have been published recently dealing with the topic of marketing in the construction industry. Marketing, which has been used extensively in the manufacturing business for years, is very applicable to the construction industry. In the past, each company has relied heavily upon reputation and trade magazines for their sole source of advertisement. Today every company including the small contractor with local flyers are learning the marketing business [Fortune, 1984 and Groob, 1987]. Another very interest response was the difference in views between the large contractors and smaller contractors in the area of training, estimating, and scheduling. The large contractors in almost every category rated this item lower on the potential for productivity increase scale then did the smaller contractors. It is obvious that the large contractors feel they have hired the best in the industry, in way of estimators and supervisors, while the smaller contractors feel like they can improve upon their estimators and supervisors. The results are not surprising since the larger contractors can afford to pay the higher salaries for the more talented people. The contractors are universal in their

agreement on the potential for productivity improvements with the modification of government regulation.

Regarding the issue of unionized labor the contractors were all very hard line in answering the survey. The author stated after talking with individual contractors face to face many of the presidents and vice presidents softened their opinions on the amount of productivity improvements that can be gained through the unions. However, those companies that worked a lot of government contracts felt strongly about the Davis Bacon Act and how the unions treat the Davis Bacon Act. The impact of unions on productivity will be dealt with later in this chapter in detail.

Although the advances in equipment in the last couple of decades has been great, the contractors all feel there is a medium potential for more improvements. One of the most commonly mentioned areas of opportunity for productivity improvement is the replacement of labor with equipment. Unfortunately the attitude we instill in the laborers sometimes reflects the unimaginative way with which we occasionally approach the productivity issue. Anyone that has worked awhile in the construction industry has seen a group of laborers with their supervisor wait for a piece of equipment several hours for a job they could have done manually in a couple of minutes.

One of the areas polled in the survey is how the contractors feel about the potential productivity increase with the use of robotics, which is another issue covered later in the chapter.

The surveys conducted by the Chicago Institute of productivity serve a very useful purpose in highlighting the issues and attitudes in the construction industry. Hopefully with time the survey respondents will increase in number rather than decrease [Arditi, 1985 and Choromokos, 1981].

RESEARCH AND DEVELOPMENT

Numerous studies have examined the relationship between productivity and research and development (R&D). Most researchers have expressed the relationship in terms of a rate of return on money invest in R&D. Although various researchers have calculated widely different rates of return, almost everyone has found that the rate of return is positive (i.e., money invested in R&D produces savings from increases in productivity that exceed the investment).

The fact that R&D can contribute to higher productivity has been recognized for many years. Thus, in the past when productivity problems of the construction industry have been analyzed and discussed, one frequently identified cause has been insufficient R&D [Summary, 1983]. However, because investments in R&D can contribute to productivity growth does not necessarily mean that the converse is true: that stagnant productivity is due to inadequate investment in R&D. In fact, various reasons beside insufficient R&D have been given for the lack of productivity growth in construction. For example, the lack of investment in capital equipment, the fragmentation of the construction industry, and out-of-date-management to name a few. It is possible, however, that many of the contributing factors

mentioned and alot not mentioned may not have been a problem if more R&D had been performed, particularly R&D relating to the management of construction.

Using 1984 numbers as a percent of sales, the pharmaceutical industry spent about 7% on research, the aerospace and automotive industries spent about 4%. The Japanese construction industry spent about 3% and the United States construction industry spent about 0.01% on Research and Development. This compares with the amount of research and development done on razor blades that year [Fox, 1986]. The amount of money invested in R&D in the United States has become a considerable to concern to some of our trading partners. The research and development program in the United States has been rated as pathetic as recently as 1984.

As part of the studies and findings of the Business Roundtable construction industry cost effectiveness project, much needed emphasis on R&D in the construction industry has now been placed. The money that is coming in now from private business is not overwhelming, however, it is much higher than before the Business Roundtable reports were released. The Federal government is also getting involved with the National Science Foundation calling for ways to spend the 1.5 million dollars in federal grants from 1985 [ENR, 1984]. The Federal government has a very large stake in the productivity of the construction business, not only from the role as big brother, but also as a 50 billion dollar a year client. The productivity centers and institutes are playing a leading rule in awarding and monitoring the R&D being conducted in numerous areas. The trend for small

contractors to participate is still not encouraging. None of the interviewed companies with the exception of Bechtel contributed any funds to research and development. Some of the reasons are listed:

1. A belief that on site construction is a service industry and that responsibility for conducting construction R&D rests primarily with the manufacturers of the equipment, products, and materials used by the industry.
2. A belief that it seldom pays a construction contractor to conduct R&D because the results of construction related R&D generally can not be patented, and competitors will quickly learn of and use anything worthwhile that is developed.
3. A belief that overhead expenses like R&D must be kept to a minimum in order for a construction firm to survive the periods of low activity that are common and inevitable in construction.
4. A belief that only very large organizations can afford to conduct R&D.

Of all the money being spent on R&D in the construction industry, the Business Roundtable found that manufacturers of construction products and equipment probably account for almost 69 percent of all construction related R&D in the United States, government agencies for about 18%, contractors for about 4%, and all other elements of the building community for about 9% [CII, 1986]. The list of the companies and federal agencies investing in construction research and development has grown considerably since the release of the Business Roundtable reports. Figures

for 1985 have not been tabulated yet but the trend of expenditures is probably in the positive direction.

The lack of R&D money does not mean there is a lack of human and physical resources needed to effectively carry out a significantly expanded construction R&D effort. There are plenty of researchers and laboratory facilities to carry on the needed R&D. The Business Rountable identified over 180 organizations in the United States with a potential for doing construction R&D. Although relatively few academic institutions currently provide research or for that matter educational programs in the management of construction projects the number would certainly increase with the dollars available.

UNION AND OPEN SHOPS

Several of the myths about productivity deal with labors and unions such as:

Myth #1. The work ethic is disappearing. People no longer believe in the virtue of hard work and care nothing about personal pride of accomplishment.

Myth #2. Organized labor's resistance to change in work practices cuts productivity.

The statistics being published these days just do not provide evidence to support these myths about productivity [Buehler, 1981].

In fact, the labor unions decreased in size from 20.1 million in 1980 to 17.4 million in 1984. A decrease of 2.7 million workers. Historically the main source of union members, non-agricultural goods-producing industries are mining,

construction, and manufacturing. These industries suffered a net employment decline of 800,000 workers over the period of 1980 to 1984. The construction unions decreased in size and number by almost 7%. This was taking place during the period of slow activity in the construction industry. By 1984, employment in the construction industry had returned to its 1980 level of 4.4 million. During the slow down of the late 70's and before the 1980 mini recession the number of union members had stood at 1.4 million for 4.4 million employees, however, by 1984 the unions stood at 1.1 million. The competition between union and nonunion contractors during this period intensified, with many of the jobs that had been historically union going to nonunion contractors. Some of the unionized firms started separate nonunion firms to compete during these lean years [Adams, 1985].

These statistics back up the economic analysis presented by Steve Allen earlier in this paper. The skill levels amassed for large projects which were historically union jobs before the slow down of the late 1970's and mini recession of 1980 have broken up into less skilled labor intensive projects. The union jobs requiring higher skill levels because of the union contracts regardless of what the actual work being done is becoming a thing of the past. Because of the mini recession, the jobs were being won by nonunion firms which had a lower ratio of skilled craftsman to laborers than the union firms. The cost difference between union and non union projects was mentioned by Mr. McNair. The company had estimated a project in Atlanta using an open shop labor source when the client stimpulated all labor must be union.

The exact same project increased in cost by 14%.

The main point of all this is the unions, although contributing to the productivity problem with outdated work practices, and higher cost on some contracts, are not the sole problem. The size and influence of the construction labor unions were dropping during the period of no or little increase in productivity within the construction industry.

The other nations of the world have suffered the same problem in that their productivity in the construction industry has had no, or very little increase. The interesting point is that they claim one of the main causes for the lack of productivity increase is the increase in labor intensive work [Hippon, 1983]. The exact opposite of what some of our experts claim. The Japanese do not blame the construction unions for the lack of labor productivity decline nor do they blame the laborers themselves.

The Japanese feel the main causes of the labor productivity decline in recent years are :

1. Reduction of order prices by excessive competition.
2. Rise in material prices following the oil crises.
3. Increase of labor intensive works, joint-venture projects and small sized separate contracts in public works.
4. Age advancement of workers.

Many of the reasons stated follow along the lines of what the United States experts feel are the reasons for the lack of productivity increase in the construction industry. However, there are some notable differences missing, one of which is that

the labor unions are at fault.

Many of the criticisms about labor unions are by companies that do alot of government work and the criticisms are really meant at the Davis Bacon Act of 1931 [Halpin, 1980]. They feel the act is outdated and no longer serves a useful propose. The act sets the minimum wage that can be paid on a government contract at the going wage rate of the local unions in that area. The act essentially makes sure that the union contractors can get government jobs. The act was not meant to do this when it was first introduced. However, it has evolved into an act that protects the union contractor and the local unions from the open shops and nonunion contractors.

Many labor unions and experts do not believe the Davis Bacon Act is outdated. They feel strongly that a higher priced union labors can survive with higher productivity rates and some work rule changes [Manser, 1985].

The labor unions are not blind to the changing times in the construction industry, nor have they been sitting around watching the demise of the union contractors. The labor unions are becoming a major contributor to the R&D efforts mentioned early. The Business Roundtable regularly invites labor union officials to join the boards and committees investigating the construction industries problems. One of the Business Roundtable reports focuses directly in on Local Labor Practices. In this report over 382 questionnaires were mailed out. Over 87% were returned, a much better result then the 1979 and 1983 questionnaires that were sent out by the Chicago Productivity Center. The

questionnaire listed 57 bad work practices observed, and requested comments and frequency of observances. The most nonproductive habits or practices reported are of particular interest:

1. Late starts
2. Early quits
3. Excessive time for wash up and putting away tools
4. Unauthorized breaks
5. Place of work is the change shack, or company property lines
6. Abuse of visits for medical aid
7. False weather excuses
8. Nonproductive work time
9. Additional time payments
10. Premiums, travel pay, incentives
11. Employment practices
12. Jurisdictional disputes
13. Steward rules
14. Manning requirements and standby time

An interesting comparison is that in many surveys on the cause of delay on the construction site, the waiting for tools and lack of tools (i.e. stolen or misplaced) always ranks up at the top.

The conclusion and recommendations made by the committee on the Local Labor Practices are well worth reading, although not described in detail in this paper, it is important to keep in mind that there are still many unproductive work practices contained in many construction labor agreements.

Some of the progress made in negotiating the labor union contracts with union contractors has occurred in areas where the mini recession hit the hardest. Because of the amount of work lost by the union contractors to the open shop contractors, the labor unions have made great advances in their work rules and negotiations with union contractors. The healthly competition has made the unions much more competitive. Some of the more notable agreements are the operation TOPP, a coalition of

construction contractors and labor unions, in the greater Cincinnati area. Started in 1981 the agreement affected $517.5 million dollars worth of construction. The best thing about operation TOFF is the cooperation among the different groups of people involved in the projects. The agreement sets rules for solving jurisdictional disputes quickly. The agreement also reduces, if not eliminates, work stoppages on the projects covered under the agreement [Hartel, 1985].

Another Labor management agreement is operation MOST in Columbus, Ohio. Similar to the operation TOFF it is another example of the strides that are being made by the unions to become more competitive with the open shops and there by more productive [Maloney, 1984].

The influences that the unions and the open shops place upon productivity are great, the level of effort of each is directly reflected in the productivity rate of a project and the industry. However, to blame the past lack of increase in productivity on the unions and open shops is unreasonable and inaccurate. Each plays its part but is not the controlling element. As one can see there is no single element that is controlling the productivity rate in the construction industry.

The healthly competition between the two should never be stopped. Not by the government and not by the industry, unless we plan on changing the way the free market place should run.

GOVERNMENT REGULATION

It is very interesting and not very surprising that so many American contractors feel they can improve greatly in the

productivity on the construction site if the governmental regulation is stopped or at least decreased. A good number of contractors list the government high on their list for the lack of growth in the construction industry productivity.

Not all nations feel this way. In Japan, the construction contractors rate the government number one for saving the industry during the past hard times. The contractors in Japan praise their governments leadership rule in setting up schools, training centers, sharing of technology advances, enforcing building codes, and guiding the contractors through the tough times with an ample supply of public work jobs [Hippon, 1983].

The amount of regulation in the United States verses Japan is not enormous, each has its building codes, each has several levels of government, each monitors and directs to some extent. Then what is the difference? Why do the American Contractors feel so strongly about over government regulation?

One of the major differences is the clarity with which the laws and regulations are applied. For example in the United states only 33% of the building departments have published guidelines on procedures [Report E-1, 1982]. If one is not a local construction manager or contractor then you have to learn the system. There are numerous other examples but the point is the Japanese are very clear and precise in the implementation of their regulation and assistance. The United States is not. The number of departments in the United States regulating the construction industry has gone up by 230 with only 20 being deleted since 1945 [NRC, 1986] (see figure 6). The amount of

BUILDING PROCESS

DE OF FEDERAL GULATIONS*	A. Materials Acquisition/Production									B. Land Development								C. Building Design						D. Construction					E. Sale and Operation				F. Other		G. Generally Applicable	Total
	1 Market analysis	2 Financing	3 Materials acquisition	3a Materials extraction	4 Materials development	5 Product development	6 Manufacture	7 Marketing/distribution	8 Maintenance/servicing	1 Planning	2 Financing	3 Site acquisition	4 Site design	5 Permits/approvals	6 Site preparation	7 Sale/lease	8 Operation	1 Project planning	2 Project financing	3 Programming	4 Design development	5 Construction document	6 Construction compliance	1 Financing	2 Contracting	3 Sitework	4 Bldg construction	5 Compliance inspections	1 Promotion/conveyance	2 Permanent financing	3 Maintenance	4 Occupancy/use	1 Professional development	2 Coordination	1 Generally applicable	
Economic Stability	■					■		■		■					■			■											■							7
Agriculture	■	■	■		■	■	■	■		■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■		30
Energy	■																				■													■		3
Banks/Banking	■	■	■		■	■	■		■	■	■	■	■		■	■		■	■	■		■		■	■	■	■	■	■	■	■			■		28
Business Credit	■	■				■		■	■	■	■		■		■	■	■	■	■		■			■					■	■	■		■	■	■	21
Aeronautics						■				■	■	■							■		■			■						■						9
Commerce		■	■		■	■	■	■		■	■	■	■	■	■			■	■		■	■	■	■	■		■							■		21
Commercial Practices		■			■	■	■	■	■				■	■				■		■		■	■					■	■	■						15
Commodities/Curities										■	■					■		■		■									■							6
Power and Water	■		■				■			■	■						■																	■		7
Customs			■		■	■																			■											4
Employee Benefits							■								■											■						■		■		5
Food and Drugs					■	■	■																													3
Foreign Relations	■																																			1
Housing			■					■	■	■	■		■	■	■	■		■	■		■	■	■	■	■	■	■	■	■	■	■			■	■	24
Indians		■	■		■	■	■	■		■	■	■	■	■	■	■		■	■	■										■						17
Internal Revenue																																			■	1
Judicial Administration	■																	■							■											3
Labor			■		■	■	■	■	■			■			■		■								■						■					11
Treasury																															■					1
Navigation																									■	■	■									3
Government Mgmt.												■																								1
Parks, etc.			■									■			■																					3
Patents, etc.	■	■	■		■	■		■																								■				7
Pensions							■				■								■		■			■	■		■	■	■	■				■		11
Environment	■	■		■			■			■	■	■	■	■	■			■	■	■	■	■	■	■		■	■			■				■		21
Public Health	■	■	■		■	■	■	■		■		■		■			■	■	■	■	■	■	■	■	■	■	■	■			■					23
Interior	■	■	■							■		■		■	■	■	■	■		■	■	■	■					■	■	■	■	■		■		20
Welfare												■		■	■		■				■	■	■					■						■		9
Transportation	■		■					■		■	■							■	■	■	■	■	■	■	■					■						14
Wildlife	■	■	■							■		■	■							■	■							■						■		10
	14	11	14	1	10	13	12	11	5	15	12	13	9	9	13	6	7	14	11	10	13	10	9	10	11	7	8	9	9	11	8	4	1	13	3	
TED STATES CODE**																																				
Agriculture	■	■	■	■	■			■	■	■	■	■	■	■	■		■	■	■		■		■	■					■	■				■	■	23
Arbitration																		■				■			■			■		■	■					6
Banks/Banking	■	■				■	■	■		■	■			■	■			■	■	■	■		■	■	■	■	■	■	■	■	■	■		■	■	25
Census	■																																			1
Commerce & Trade	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■		■			■	■		■	■		■		27
Conservation			■	■			■			■		■	■	■	■			■			■		■				■	■			■			■		15
Education		■								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■		■		23
Foreign Relations	■			■						■		■		■	■		■	■	■	■	■	■	■		■	■		■	■		■	■		■		20
Internal Revenue																																			■	1
Labor			■			■	■	■			■	■			■		■	■		■			■		■	■	■	■			■			■		17
Mining			■																																	1
Money/Finance		■									■								■					■						■						5
Navigation			■							■	■	■	■	■	■		■	■	■	■	■	■	■	■		■			■		■	■		■		20
Veterans										■	■	■	■	■				■	■	■	■	■	■	■			■	■	■	■	■	■		■		19
Postal Service			■					■				■																	■			■				5
Public Buildings	■	■	■	■	■	■	■	■		■		■		■	■	■		■	■	■	■	■	■	■	■	■	■	■	■		■			■		28
Public Contracts	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■			■	■	■	■	■	■	■		■			■		28
Health & Welfare																																				
Public Lands			■									■		■																						3
Railroads			■					■			■								■					■												5
Telegraphs, etc.													■	■	■							■	■					■	■		■		■	■		10
Territories										■	■	■		■				■	■					■	■				■					■		10
Transportation			■	■				■		■	■	■	■	■	■				■	■			■		■									■		14
	7	7	12	6	4	5	6	9	3	12	12	14	9	14	12	4	6	13	13	10	9	7	13	10	9	6	7	11	12	6	12	8	1	14	3	

umber reference refers to regulations listed in the Code of Federal regulations.

umber reference refers to statutes listed in the United States Code.

GURE 6. Regulations and codes affecting the building process (from National Institute of Building Sciences, *A Study of Regulations and Codes Impacting the Building Process*, Washington, D.C., 1979

documents and paper work created by the increase of government agencies is staggering. Many American contractors avoid government work if they can do to the amount of overhead that is required to keep up with the government regulation and documentation. Although no figures are available to support this, after talking with people in the construction industry this fact does become apparent.

The largest and most heard complaint by contractors that do government work is the restriction imposed by enforcement of the Davis Bacon Act. As described early this act affects only work done on government projects which includes state projects using federal government funds. The act sets the pay scales for the projects at the local union rates thereby making sure the union contractors are not excluded from doing government work.

The paper has discussed the negative influences of government on the construction industry according to some vested groups. Now the paper will briefly mention some of the importance of the government in the construction industry.

The leadership rule of the government is vital to the construction industry and for the most part is well done. There are segments of the construction industry that are better led by government regulation than others. The nuclear construction industry is an example of probably the worst in the way of clarity and consistency.

The financial role the government plays in the construction industry cannot be understated. In FY85 the federal government construction expenditures exceeded 50 billion dollars. Many of

the contractors in the United States would not be very healthly if it were not for the Federal Construction Programs. The reciprocal of this is the government is very concerned about productivity in the construction industry to make sure it continues to get its money's worth.

The government has initiated countless programs to promote industrial innovation or scientific or technological development of some type, and while many have been successful, many others have failed. The point being that the successes has assisted many contractors in staying in business.

Government regulation needs to be continually reviewed and improved and that is the job of committees such as the Business Roundtable and institutes such as the Construction Industry Institute in Austin, Texas. To place the blame for the lack of productivity growth on the government is not only inaccurate it is wrong. Just like other topics discussed,the government had and still has some of its policies's that contribute to the problem but do not solely influence the situation.

ENGINEERING AND DESIGN STANDARDS

Engineering and design standards have a great influence on construction productivity. Some projects give more emphasis on the economics involved than do others. Such concepts as valve engineering and turnkey projects have resulted from the conceived gains in productivity and cost reduction.

CONSTRUCTABILITY

The construction manager is highly interested in the construcbility of the project which is an offshoot of value

engineering. CII defines constructability as the optimum use of construction knowledge and experience in planning, engineering, procurement and field operations to achieve an overall objectives [Summary, 1983]. The objectives are obviously constructing the desired project at the least cost to the owner with the most profit for the contractor. Some of the consideration in design constructability are:

1. Construction driven designs. The design should be enhanced to consider the construction schedule and materials required.
2. Design simplification. The design should be as simple as possible and still give the final desired outcome. This includes the specification of local material, using standard lengths and dimensions, making the blue prints easily to follow to limit the mistakes by the crews.
3. Standardized designs. This eliminates having to learn a new construction technic and retrain the crews. The bugs within the design are worked out and improved. The best example of standardized designs are those used by the fast food chains.
4. Designs and prefabrication. The use of prefabraciation quickens the project time and lessens the crowding on the work sites. Usually prefabrication lowers the unit cost.
5. Accessibility. The design should be site specific, including geography, layout areas, and other normal requirements.
6. Design should take into account weather. The construction techniques used should consider the historical weather pattern during the proposed construction period.
7. Designs should include specific specifications. The use of

"boiler plate" specifications should be avoided. Although they save the owner a little bit of design money, they normally end up costing alot of construction money in change orders or material not really needed or desired [O'Conner, 1987].

It is hard to overcome some of the barriers to constructability designs and integration of the old design technique and the new. Several of the barriers frequently encountered are:

1. Resistance by owners. Constructability programs add highly visible extra cost to projects.
2. Tradition. It is hard to get the construction and design industry to change.
3. Resistance by engineers. Construction experts are not always welcomed by the engineers.
4. Shortages of qualified personnel. The number of construction managers is still limited. The communication between construction managers and engineers is usually better than that between the project superintendent and the engineers.
5. Training. The schools are not putting much emphasis on constructability in the design classes.
6. Incentives. The incentives for the contractors are minimum except on some contracts. There is normally more money to be made through change orders.
7. Priority. Most owners are not aware of the potential savings by using constructability.

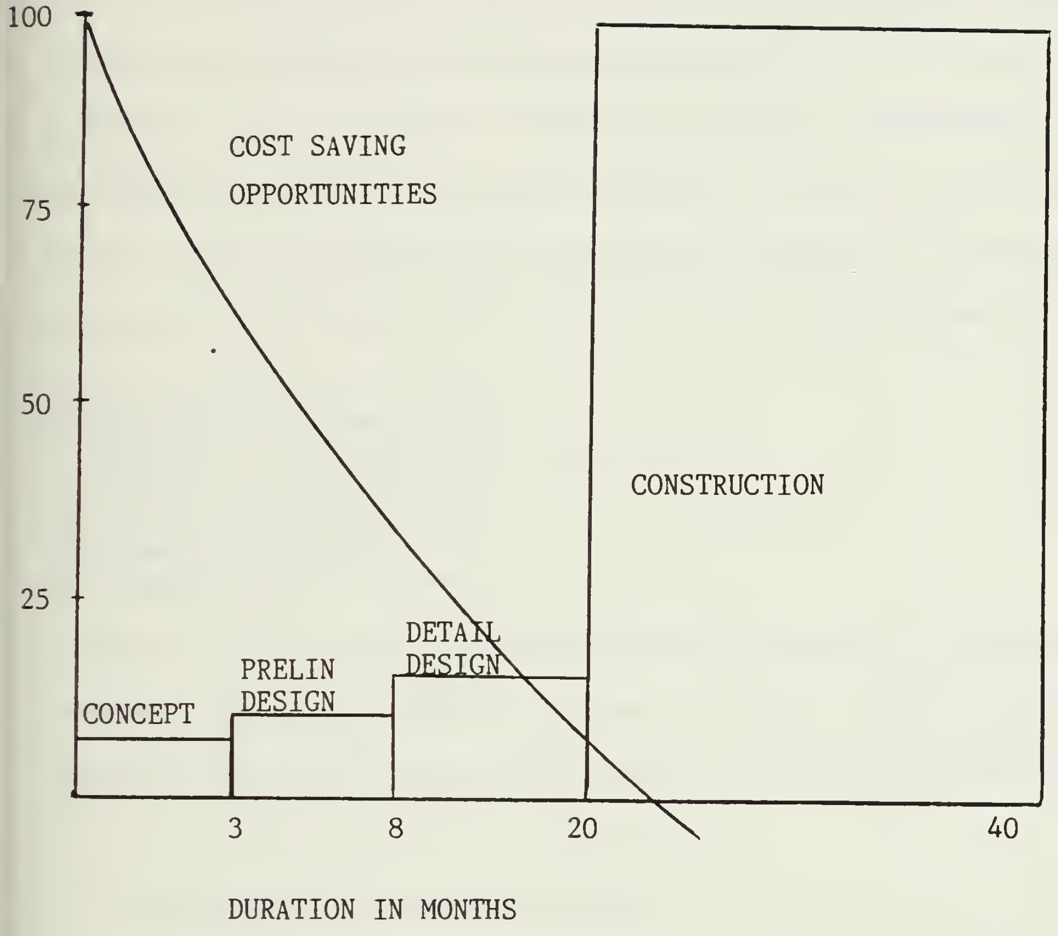
The most important point to remember is that a few dollars

and extra time spent in considering and designing in constructability will return the investment many times during construction. The construction manager representing the owner is not providing adequate services if he does not emphasis this point. The hard part is recording any cost savings since the construction budget is finalized after the constructability has been designed into the project. It is hard to document the savings to the owner unless you design the project and price it without the constructability designed in it. Mr. Ray during his interview discussed their companies attempt to document the cost savings of value engineering. He agreed the potential for cost savings start at the beginning of the design phase and steadily decrease as the project enters into the construction phase. (see figure 7)[Shah, 1984]

VALUE ENGINEERING

Value engineering is closely related to the constructability concept, unfornatuely sometimes it assumes the construction manager is acting more as just a contracting agent and has no input into the design. The idea behind value engineering is the improvement of design by encouraging the contractor or a construction expert to make suggestions and recommendations during the design. The contractor receives monetary incentives for giving cost saving ideas. The monetary incentives vary from contract to contract.

Constructability and value engineering as you can see are very similar and with either one implemented the productivity rate of the construction effort should be greatly enhanced.



"PROJECT LIFE CYCLE, EFFORT, AND OPPORTUNITIES"

FIG. -7

Taken from Construction Management: Marta In Retrospect, Journal of Construction Engineering & Management, Dec. 1984

ROBOTICS

Robotics is a relatively new topic to the construction industry as a whole. Robotics has received a cautious reception in the construction industry as might be expected from an industry as fragmented and diverse as it is. The potential for productivity increase and cost savings is enormous. But the slow moving construction industry feels a little threatened by the break in traditional ways of doing business. Some of the myths an worn out sayings still raise their ugly heads:

Each project is unique
Robotics takes away jobs
The capital investment is to much
Its not the way we do it
The union won't like it
The men won't like it
Management won't like it

Like it or not robotics has found its way into the manufacturing industry and is finding its way into the construction industry. Some of the uses found for robotics in the construction industry are:

1. Painting of interior walls.
2. Plastering of the exterior wall of a building.
3. Spreading of resilient flooring on a large floor.
4. Casting of pumped concrete with a tele-operated arm.
5. Reinforcing bar fabrication robot.
6. Tunnel lining robot.
7. Bricklaying robot.

These are only some of the already developed uses of robots in construction [Crowley, 1985 and ENR, 1983].

We are not the only country trying to develop robots for use

in the construction industry. Japan has made great strides in the development of robots in construction and they have one other major advantage over the United States. They use them!

The social aspects of robots in the construction industry will require a great deal of attention and care. It will involve displacement of some labor and redefining the tasks of others. Robots do raise legitimate fears within construction labor as well as lower management on the construction job sites as to their job security. Fears may prevent labor cooperation in the implementation of robotics which will most certainly impair their effectiveness. Efforts must be made to reach an understanding as to the priorities and policy of implementation of the robots [Crowley, 1985].

The need for robots is becoming critical. As the labor shortages become more and more, critical pushing the average wage higher and higher, the productivity measures we use to day are going to get worse and worse [Hammonds, 1987]. Some technological advances will improve productivity without the implementation of robots but by the end of the decade this will not be enough. The labor department predicted in a 1980 report that 2.4 million new construction craftsmen will be needed by the end of the century. During a period of population decline. The shortage is not far off, by the year 1990 there will be a shortage of 1.9 million construction workers. The current training programs produce only 50,000 craftsmen annually [Newman, 1983]. As the need for people in all the industries goes up so will the wages being paid. The construction industry is going to

become more unproductive and costly than ever if we do not start to plan for the labor shortage now.

The unions and management should plan now for the procedures for implementing the robots and retraining the laborers displaced into fields where the robots are not applicable. The contractors, through the Construction Institutes, should start investing in the near future to lower the possibilty of having to buy most of the construction robots from the Japanese and Germans in the future. The manufacturing industry has made the change and the construction industry should learn from their lessons. Robots are not new, and they are being used to some extent in the construction industry already. However, not on the scale the near future will require, if the construction industry plans on improving its productivity.

SAFETY

Safety has always been a key concern in the construction industry. Some companies are more safety conscious than others and their insurance rates show it. Safety has an enormous impact on the productivity of the construction industry. Job site accidents and work related injuries and illnesses, including fatalities, in construction occur at a rate that is 54% higher that the rate for all industries, making it one of the most hazardous occupations. With 8% of the nation's work force, construction accounts for over 10% of all occupational injuries and 20% of work related fatalities [Newman, 1983].

The United States does not have an unusually high accident rate in the construction industry, it is universal to the

construction industry. Japan has about the same percentage of accidents on the job site as the United States [Hippon, 1983].

In addition to the humanitarian reasons for preventing personal injury, the 8.9 billion dollars a year cost of accidents gives the construction manager, contractors, and owners every reason to bear down on safety. Especially the owners since they eventually pay for it.

Past research by the Business Roundtable has shown that accidents are, to some extent, controllable by all levels of construction management. A reasonable reduction in the frequency and severity of accidents would lower the 8.9 billion dollar direct cost of accidents by as much as 2.75 billion dollars, or 8% of direct construction labor payroll a year. The direct cost does not include the clean up cost of an accident, the lost time, the work slow down that will follow, or the cost of the firms reputation[Report A-3, 1982]. The owners pay for a bad safety record in the cost of their projects. OSHA conducted a study and determined the owners with construction accident rates lower than the industry normal followed some simple guidelines:

1. All owners with better than average construction safety records required constructors to apply for work permits to work in areas that were considered dangerous by the construction manager.
2. The owner took into account the contractors safety record when awarding or negotiating the contract.
3. All the owners in this group conducted on site safety inspections of their own.

The cost of safety and the lack of safety is a direct influence on the construction industry productivity rate. The construction manager that ignores safety or does not place the proper importance on safety is a danger to the industry and himself. There are hundreds of established safety programs, it is not the purpose of the paper to discuss those various programs, except to say that safety has a major direct impact on construction productivity. Every safety program, regardless of the level of detail on paper is of questionable value unless common sense is applied by the construction manager. It is everyone's responsibility and obligation to get a project completed safely, to do any less is criminal.

OVERTIME

The use of overtime in the construction industry is well documented and still widely used. The effectiveness of overtime is also well studied and widely distributed. The hard part to understand is why the construction industry, on a regular basis, still uses prolonged scheduled overtime. Scheduled prolonged overtime on large projects is known to disrupt the area's economy, reduce labor productivity, inflate labor cost, and without much hope for a pay-off of an early completion date.

The Business Roundtable has done extensive research into the use of overtime on construction job sites and recommends that all owners force the contractors to limit overtime worked [Summary, 1983].

The Department of Labor indicates that the most effective method, in terms of productivity, to add extra hours beyond the

normal 40 hour week is to hold the eight hour per day constant and add an extra day. Scheduled overtime, by definition, involves regular work for more than 40 hours per week. It is distinguished from the intermittent overtime required to finish a concrete pour, or to do emergency work of short duration.

The Business Rountable studies on overtime were based on engineering standards for a given task. They compared the actual times taken to do the work per unit using overtime verses the set engineering standard. For example the study found that the productive output of carpenters over a prolonged period of time was:

8 hour day	completed units	120 pieces per hour
9 hour day	completed units	100 pieces per hour

It is obvious to see the benefit of increased hours is short lived [Report C-2, 1980].

Besides the extra cost associated with the use of prolonged overtime other problems start such as:

fatigue
absenteeism increase
mental attitude decrease
higher personnel turnover
increase in accidents

The study concluded that when a work schedule of 60 or more hours per week is continued longer than about two months, the cumulative effect of decreased productivity will cause a delay in the completion date beyond that which could have been realized with the same crew size on a 40 hour week!

Anyone that has worked overtime for a prolonged period of time will testify to the accuracy of the studies findings. Most people will slow their pace to get the same amount of work done

in eight hours as ten, if worked for prolonged periods of time. It is not something easily overcome. The study justified working for prolonged periods of overtime in remote areas where the cost of housing and taking care of the workers is high. It takes alot of the construction managers time to schedule work so as to avoid the human tendency of work slow down during periods of prolonged overtime [Report C-2, 1980].

The effects of overtime on the productivity of the construction industry are obvious, yet greatly ignored. The contractors still work a lot of prolonged overtime, some say it's to attract and keep their workers. The problem is the statistics just do not back up that philosophy; prolonged overtime causes a higher turnover rate. The owners and construction managers will have to act to keep overtime use down, for its intended short term objectives, on the average project.

WEATHER

Everyone that has worked on a construction site knows how the weather can effect the schedule, and also knows there are means by which one can act to accommodate the weather's activity. The construction managers skill in scheduling and shifting work is the secret to dealing with weather and a little bit of luck.

The weather effect on productivity should be very minimum if the original productivity rates anticipated took the historically normal weather conditions into account when the engineering standards where being developed. The cost of a project is dependent on when the construction is scheduled and if the area has varying or adverse weather patterns. What we really are

discussing when talking about weather related productivity is the deviation from the planned construction productivity.

A number of studies have been done on weather and most estimating books have tables and adjustment factors for the time of year and location of the site were the construction is planned [Navfac, 1983]. It is the clients decision whether to build in the bad weather season with a lower productivity rate or whether to wait for better weather with a higher productivity rate.

A construction worker's productivity is, of course, greatly affected by weather, both psychologically and physiologically. [Koehn, 1985]

With the proper decision tools, information and experience, the construction manager and the owner can make the correct decisions and make the necessary trade offs made. The accuracy of the productivity estimates depends upon it.

CHAPTER FOUR

HUMAN INCENTIVES AND MOTIVATIONS

INTRODUCTION

The measurement of productivity in the construction industry is usually expressed in some form of labor input as we have seen earlier in the paper. The construction industry has taken a keen interest in labor motivation because of the falling productivity rate in the industry. Some feel the major area of concern is the multi-faceted problem in worker motivation [Report A-2, 1982]. They feel construction workers seem to take less pride in their work than was true in past years. The work ethic seems to have weakened, possibly because of social welfare programs, unemployment benefits, or for some economic prosperity. Labor makes up a large part of the cost of any project, ranging from 25% to 40% of the total project cost. This cost only reflects the labor charged to the project cost account codes and does not include the labor cost, for example, of the material delivery company. The labor cost is counted as a material cost, it is charged against a material cost account.

Increasing labor efforts such as overtime do not always equate to increased productivity. To get an increase in productivity we must increase the output side of the equation at a higher rate then we increase the input. Unfortunately, this is easier said than done most of the time.

There was a time when worker satisfaction was thought to be closely related to worker productivity. That is, satisfaction was linked to high productivity and dissatisfaction to low

productivity. The relationship between attitudes and productivity, as ample research has shown, is not a simple matter. Worker productivity, in terms of rate or quantity of output, is at best weakly related to worker attitudes. However, when worker productivity is considered in terms of lack of absenteeism, low turnover, and other forms of withdrawal from the job, a relationship between productivity and satisfaction exists. Those workers most satisfied are those least likely to withdraw. Job satisfaction and other worker attitudes thus bear an important relationship to some aspects of worker productivity but not to others [Guzzo, 1983].

Construction workers can be motivated to increased their productivity rate. Many companies have instituted programs that have worked. The Business Roundtable has recently done a survey and study on labor motivations and recommends that construction companies install motivational programs. As we will see later there are numerous types and variations of labor motivational programs, but first we need a quick review of the different theory's regarding human motivation.

THEORY'S

MASLOW HIERARCHY

The first theory that everyone should know or have at least heard of is Maslow's hierarchy of needs. Maslow describes man as a "wanting" creator, and his wants in turn become "needs" that man tries to satisfy. These needs are not only physical, to be satisfied by material things, but also psychological. Maslow developed a hierarchy of needs that goes a long way toward

explaining many of our human behaviors.(figure 8) The theory proposes that man first satisfies his most basic needs, once these are satisfied they are replaced by new needs and he is motivated to attain these. Needs once satisfied are no longer motivator's, but there is always a need to replace the old motivator with a new one.

Man's most basic needs are physiological, that is they sustain life and provide physical comfort. For example food, clothing, and a house. In the hierarchy, only after these needs are near fulfillment, does man seek safety, love, esteem, and self fulfillment. If one of the needs is not fulfilled the desire to satisfy the need will increase, then irritation will develop, and then unnatural behavior will occur.

Maslow has always been the first to point out the needs are not always filled in order, since higher needs may occur before a more basic one is completely satisfied. He also stated the needs vary in there importance in each individual and even daily variation within the same individual [Drewin, 1982].

The important thing to remember because it will be used later, is that the more a need is satisfied, the less it motivates behavior. For example, once man is earning sufficient money to gain him food, clothing, and a house that he considers appropriate, he becomes motivated by higher needs such as security and status.

THE X & Y THEORY

The next theory that will be useful in describing and developing a motivational program for construction laborers is

MASLOW'S HIERARCHY OF NEEDS

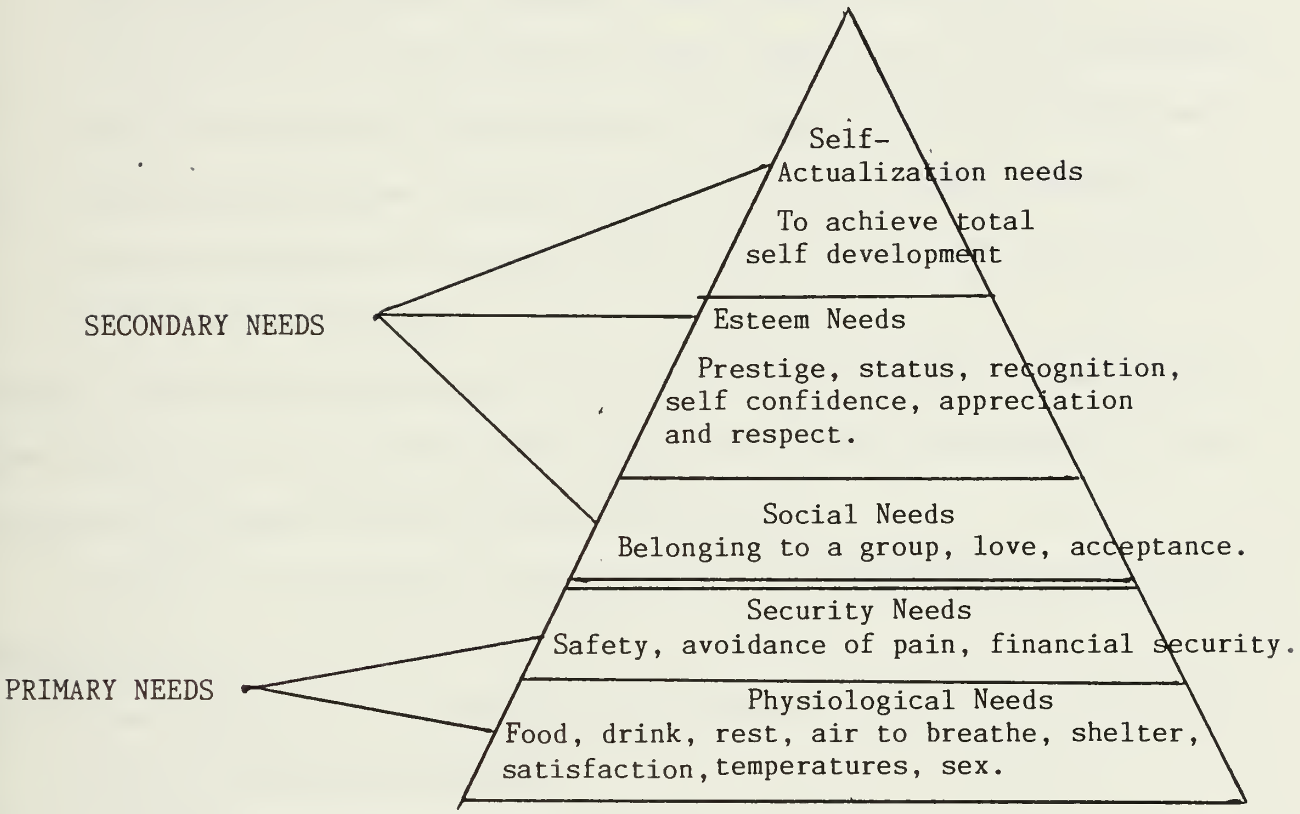

Self-
Actualization needs
To achieve total
self development
Esteem Needs
Prestige, status, recognition,
self confidence, appreciation
and respect.
Social Needs
Belonging to a group, love, acceptance.
Security Needs
Safety, avoidance of pain, financial security.
Physiological Needs
Food, drink, rest, air to breathe, shelter,
satisfaction, temperatures, sex.
SECONDARY NEEDS
PRIMARY NEEDS

FIGURE 8 [Drewin]

the X and Y theory. This theory, developed by Douglas McGregor, refers to the traditional two different types of views on humans in the work place. Theory X states:

1. The average human being has an inherent dislike for work and will avoid it if he can.
2. Because of this human characteristic of dislike of work, most people must be coerced, controlled, directed, threatened with punishment to get them to put forth adequate effort toward the achievement of organizational objectives.
3. The average human being prefers to be directed, wishes to avoid responsibility, has relatively little ambition, wants security above all.

Theory X was the traditional view of the human work force during the industrial revolution years ago and is still applied in many industries today but with less enthusiasm.

Theory Y is exactly the opposite, it rests on the following assumptions:

1. The expenditure of physical and mental effort in work is as natural as play or rest.
2. External control and the threat of punishment are no the only means for bringing about effort toward organizational objectives. Man will exercise self direction and self control in the service of objectives to which he is committed.
3. Commitment to objectives is a function of the rewards associated with their achievement. The most significant of such rewards, is the satisfaction of ego and self

actualization needs, can be direct products of effort directed toward organizational objectives.

4. The average human being learns, under proper condition, not only to accept but to seek responsibility.
5. The capacity to exercise a relatively high degree of imagination, ingenuity, and creativity in the solution of organizational problems is widely distributed in the population.
6. Under the conditions of modern industrial life, the intellectual potentialities of the average human being are only partially utilized.

Today, construction management generally leans strongly toward the authoritarian theory X approach. However, because the dependence of the laborers is changing, so is the level of authoritarian approach. Figure 9 provides a good graphical representation of the way things are going and must go if the productivity level of the construction industry hopes to make up some lost ground.

The more contemporary behavioral scientists question the adequacy of the two mentioned theories. In the past, the majority of the research on construction labor motivation shows that most of the research was based on the motivational theories of Maslow. Few of the studies were based upon empirical evidence and have come under great criticism. The contemporary behavioral scientists now use a set of guidelines and formulas that can be derived using the more generally accepted expectancy theory of work motivation. Since we are only interested in the basic

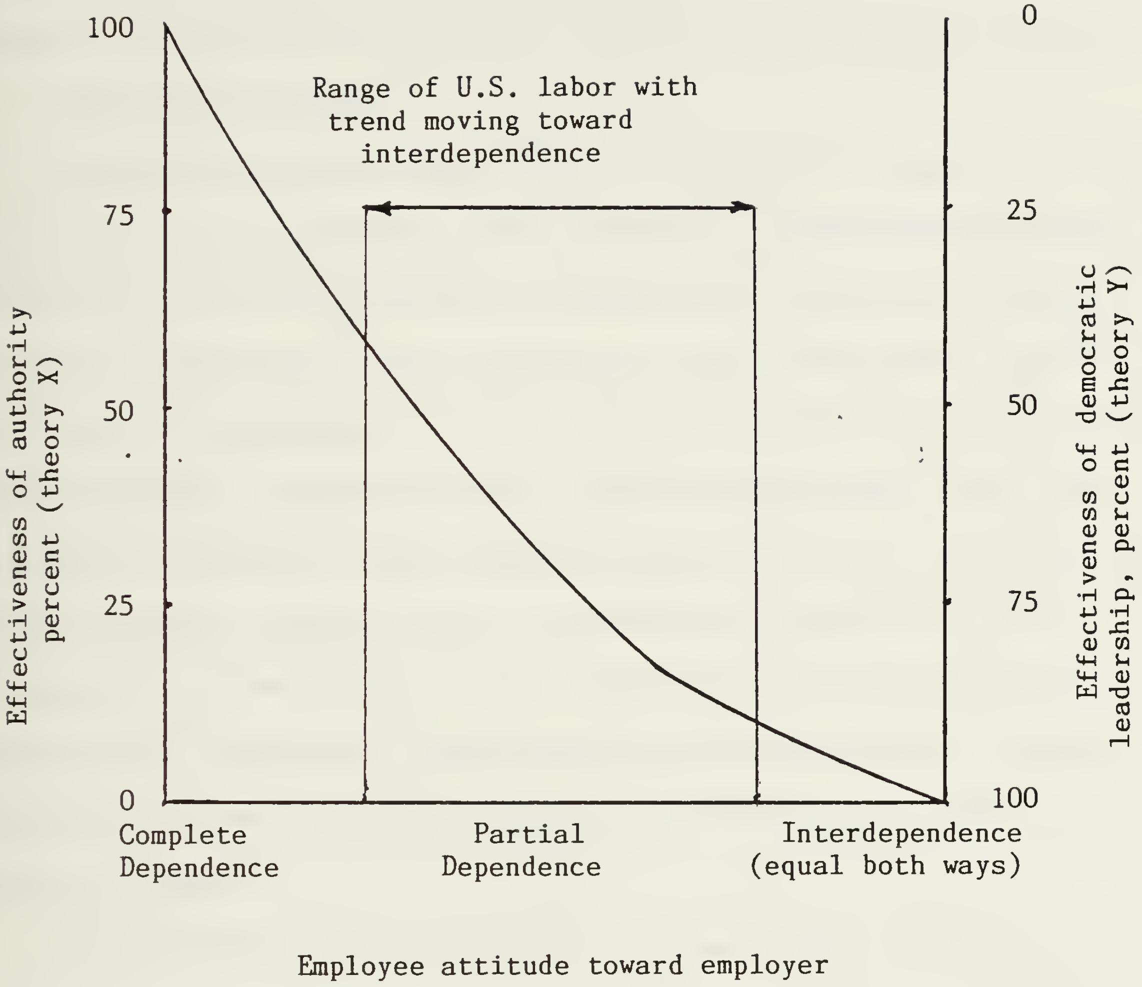


FIGURE- 9 Relative effectiveness of authoritarian and democratic leadership in today's labor management environment. [Parker]

premises of the expectancy theory, we will not redevelop or review the formulas and tables derived from the expectancy theory. Instead we will briefly review the concept of expectancy.

EXPECTANCY THEORY

Expectancy theory deals with three major sets of variables, and stresses the necessity of analyzing relationships among these variables as a prerequisite to understanding the motivation process. The three major areas are, the individual, the job, and the work environment. It also recognizes that different people have different types of needs, desires, and goals, and not everyone values the same rewards equally, or are motivated by the same stimulus. People work to accomplish something for themselves. They have a task that must be performed and by performing that task, they hope to receive rewards. These rewards, or work outcomes, serve as the means of satisfying the workers needs.

Expectancy is the connection between the laborers expenditure of effort and his performance of a work activity. It is defined as the laborers subjective probability that he can turn his effort into unto a successful completion of the work activity. An expectancy valence such as 0 indicates that the individual perceives a neutral chance of being able to perform the task if he tries to do so. Expectancy valence's are assigned using the modeler's experience and knowledge of the subject. The full range of valence may be from -1 to +1. A assigned valence of +1 indicates that the worker perceives the outcome as having a great ability to satisfy his needs. A valence of -1 is perceived

as eliminating current and preventing future satisfaction. An outcome with a valence of 0 is seen as being neutral, neither having the ability to enhance nor prevent future satisfaction. The more attractive the performance of a task, the more motivated the worker will be to perform it. Attractiveness is the expected value of the anticipated satisfaction of the rewards or outcomes associated with the performance of a task [Maloney, 1983].

None of the thoughts involved in the expectancy theory are new, however, through the proper development of values for the valences, expectancy, and instrumentality, we can develop a motivation score. The expectancy theory takes what use to be a non-empirical subject and moves it into the mathematicians realm. The assignment of numbers is subjective to whomever is setting up the expectancy tables, and hopefully they are considering how the laborers feel about each job [Laufer, 1981].

The biggest draw back to the expectancy motivation theory and model is that the numerous values assigned to optimize the outcome of the activity normally exceeds what the average human will consider. People often do not consider all alternatives, and they choose a level of effort that will produce a satisfactory set of outcomes rather than the optimal. Any model must be limited to only those factors that the person is actually using as a basis for their decision.

NEEDS THEORY

Another theory, in the attempt to understand motivation, is the needs theory. Motivation has been defined as a physical or psychological drive to obtain the means to satisfy one's needs.

Needs can be viewed as physical or psychological deficiencies. Laborers start with needs and seek a way of satisfying them. The laborer identifies the source of gratification that is available to him. Once identifying the source of gratification, he engages in goal or task directed behavior to obtain the means of gratification. If the means are secured, the original needs will be satisfied. Once this occurs, different, unsatisfied needs or a variation of the original needs become important.

In the needs theory, the human needs are broken down into three categories, existence, relatedness, and growth. These categories, of course, contain the need for money, security, love, fulfillment, etc.

Satisfying these needs depends upon comparing what one person gets with what others get in the same situation. Different people are satisfied by different things. Some people are happy with hot dogs and beer for dinner, others need a seven course dinner, however, both have satisfied theie need for food and are happy.

Relatedness needs acknowledge that each person is not self contained but must engage in transactions with his human counter parts and environment. Satisfying these needs depends upon a process of sharing, and the willingness to share. Each person has their different levels of relatedness. Some of the laborers need very little in the way of sharing and others are very out going and need constant sharing. Sharing can be a lot of different things both materially and concepts.

The final category is growth needs. Those are the needs

that impel a person to develop his capabilities and to attempt to employ his capabilities in different circumstances. The growth need requires challenge and a chance to grow, it involves different levels of responsibility.

The most important concept involved in the needs theory is also expressed in the other theories but not strongly enough. This is the concept of individual differences. People respond differently to situations and the responses of one person to the same situation may vary over time. This are of interactional psychology is relatively new to the scene and still has alot of on going studies.

LABOR STUDIES

The theories presented so far are used in many different combinations throughout the construction industry. There have been many studies that investigate what motivates the workers and laborers of our industry. An interesting point here is there have also been as many studies on what demotivates the workers and laborers in our industries. Many feel that the demotivator's are more important than the motivators, since once a motivator has been filled it is no longer a motivator. However, once a demotivator has been eliminated it is no longer a demotivator. Which has the longer lasting effect for the money and time spent?

The studies that have been conducted on the blue collar working class are impressive. In the last several years, alot of work has been in researching labor productivity because of the construction industries productivity problems. Since labor is such a large part of each project, labor has been studied in

great detail in an effort to improve the job site productivity. The most recent comprehensive studies have been on nuclear power plant job sites. The studies were financed by the Department of Energy. Once again the study focused in on motivators and demotivators of workers. Most of the studies actually performed by engineers have held many of the findings and conclusions developed by the social scientists as contentious. Conflicting empirical results and schools of thought have clouded the problems of human nature and productivity. The productivity studies performed by the engineers tend to get down the problems on the job site and do not deal on the physiological side of human nature. In the author's opinion, generally, they are considerably more useful then the studies by the social scientists. This is not saying the social scientist studies are not important, just not as useful to a specific problem.

The Business Roundtable has also taken a great interest in the motivation of construction laborers. They feel the key to motivating construction laborers and foremen appears to be organizing the project and its resources to let individuals be productive.

The study finiacied by the Department of Energy was conducted by the University of Texas. The study interviewed with and surveyed more than 1000 craftsmen at 12 large construction job sites. The study identified a large number of motivators and a even larger number of demotivators [Borcherding, 1980].

List of motivators found during the study:

Pay and Incentives
Suggestions solicited

Craft relations
Orientation program
Safety program
Working conditions
Overtime
Recognition
Goals
Open house (pride)
Well planned project

Additional Motivators not mentioned in the study:

Participation in decision making
Training
Leadership
Communication channels
Proper evaluations
Job Satisfaction
Security

Lists of Demotivators found during the study:

No cooperation among crafts
No communications
Unsafe working conditions
Disrespectful treatment
Little accomplishment
Material availability
Tool Availability
Rework
Crew discontinuity
Project Confusion
Productivity stressed but no goals
Poor use of crafts
Incompetent personnel
Overcrowding
Poor Q/C
Lack of decision making

Additional demotivators not mentioned in the study:

Lack of equipment
Absenteeism
No enforcement of the rules
Constant positive reinforcement
Poor goal setting
Un-informed staff members
Prolonged Overtime

The list of motivators and demotivators are specific to the craftsmen surveyed and not absolute. Some of the motivators and demotivators deserve extra comments and correlation to the human

motivation theories presented earlier.

The difference between quite a few of the motivators and demotivators is the presentation or implementation on the job site. A really good idea for a motivator can become a demotivators if not presented correctly. For example, a well planned and scheduled project can be a great motivator. On the other hand, the same project with a poor plan and schedule can be a demotivator on the site. It is always up to the construction manager to recognize this situation or at least be open minded enough to see the problem when it is pointed out to him from the muddiest laborer on the site. This is one of the reasons the Foreman Delay Survey is becoming so popular among the foremen.

The use of motivators on a project are useful but take alot of effort and time, since usually when a need is fulfilled, it is no longer a motivator for the labor. A motivational program must be dynamic to have a chance of success. A motivational program must be careful not to insult the intelligence of the laborers [Schwartz, 1986]. During a long project in Detroit, the project team and laborers were starting to fall behind schedule, so the owner brought in an outside firm to implement a productivity program. This included ball caps, buttons, and picnics. The project was completed on time but the effectiveness of the productivity program is questionable. Many of the trades saw "the whole thing as a big joke" and considered the baseball caps and advertisements patronizing. As one stated "We're professionals. We don't need gimmicks to do a good job."[Schwartz, 1986]

Contractors that work with the Business Roundtable and have experience with the cost effectiveness project criticize the program because there was no accountability. It was an advertisement program with no changes to the accounting system or the productivity system. The project schedule and planning program did not change. There are the supporters of the program who felt it helped increase productivity 18 to 20 percent.

The motivators used for the Detroit project were not overwhelming and certainly were conventional. The practice used by most other companies is an attempt to eliminate the demotivators on the job site. The demotivators appear to have a longer lasting effect on productivity when removed then the motivators do when implemented. However, there is no empirical data to support this conclusion. As a construction manager, one has an opportunity to work on solving the complaints or at least paying attention to the complaints made by the laberors. When laborers stop complaining and become quiet is when one has a real problem. The Hawthorne affect mentioned earlier has a lot of truth to it. The attention paid to your workers will be paid back normally with greater productivity. Demotivators are real problem on the job site and need to be solved for the sake of productivity.

One of the great myths about productivity was presented earlier in this section when stated that a few experts felt that the work ethic and pride associated with the construction industry had decreased. None of this can be proven and some of this myth can be disproved. The Committee on Construction

Productivity for the National Research Council did a review of the engineering standards provide by R.S. Means over the last 10 years. The results show great variation in productivity during the period for the 30 tasks investigated. Specifically, output per crew member increased for 13 tasks, decreased for 11 tasks, and remained unchanged for 6 tasks. This suggests no clear trend in construction crew productivity [NRC, 1986]. The young and old construction workers the author has worked with, like every other group of construction workers, has its outstanding performers and its non-performers. The pride in their work was not lacking in general. Only when the direction of management was, hurry up and get it done, did the quality suffer. Through the interviews conducted most did not feel there had been a general change in worker's attitudes, they had some that were good and some that were not so good.

WHITE COLLAR STUDIES

The number of studies that have been done on "white collar" motivation in the construction industry is considerably less than those that have been done on laborers in the construction industry or on "white collar" workers in the manufacturing industry. As presented earlier, the productivity measure of the professional management and engineering staff is even harder to define then for the laborers in the construction industry. The productivity problem of the construction industry, because it is not well defined, is hard to pin point. To date most of the blame has centered everywhere except on management except to say its management's responsibility, never really saying its

management's fault. It may not, no one is really sure since we cannot measure where the problem is as an industry. However, we can usually pin point the problem on individual projects which is where we should start.

The concept of motivators and demotivators is still applicable when talking about management. The list is different with different emphasis placed on the categories. The incentives and motivators will change with different economic periods. For example, during a good growth economy, there could be discretionary bonuses and profit sharing, and during a stagnant economy there could be recognition and rewards for creativity in new projects and construction methods. During the down economy frequent communication with all parts of the organization regarding costs, waste, company financial status, and possible layoffs. Nothing is more demoralizing to an organization a unnoticed layoffs and mass firings.

Incentives for management can be broken down into two categories, membership and performance. A few incentives fall into both categories. Both kinds of incentives are important; however, they do different things. Membership incentives help to keep people. They show up for these. Examples are health plans, life insurance, and pension plans. Performance incentives help to motivate people. Employees work harder for these. Performance based incentives including cash, or shares, merit salary increase, and promotions.

The human behavior theories are still applicable, but with usually slightly different weights. The removal of demotivators

still tends to have longer lasting effects then the fulfillment of motivators. The motivation of payday only last a couple of on either side of payday.

The manufacturing studies on white collar professionals have centered around office lighting, environmental effects, chair design, and office layout. All of which the average engineering firms have gained information and insight from.

The construction manager must be able to operate in both environments, the field and the office. It takes a little change in mind set each time you change locations. Different language, different dress, different approaches, and just plain different attitudes. The construction manager is master of his environment from the beginning if he takes advantage of the situation before the project begins. The selection of the engineering firms, construction firms, and project office personnel set the tune of the project for the duration. The success or failure of a project depends upon the construction managers selections. The selection of firms is out of the scope of this chapter and paper; however, the selection of personnel is well within the scope of human incentives and motivation. The construction manager can eliminate alot of his problems from the start if he makes the correct selection of personnel. It serves the construction managers ulterior motives and personal incentives to pick a successful project staff.

SELECTION METHODS

The correct selection of personnel cannot be over emphasized. The construction manager will live with the

selections made every day. If he made the right selection the project will move along with the best possible results. Pick the wrong people and things will go down hill quicker then you can imagine. If you pick the wrong personnel do not wait until its to late. Get rid of the disturbers, non performers, and trouble makers early [Peter's, 1982]. This applies to laborers as well as management personnel. The amount of time and ill feelings it takes to release someone are usually made up very quickly in productivity gains. This does not mean make the decision in haste, make sure you have identified the problem correctly and that your decision will sit comfortably with the rest of the construction team. If the decision is the correct, one will be alone in their decision, very seldom will one recieve any support from the team. If one is wrong in their decision the whole project team will be letting you know you have made a mistake and that is hard to recover from. The hardest case is when half the team supports the decision and half does not. This is all the more reason to be careful in the selection of the project team when you have the chance to choose. You can avoid alot of heartaches by making the right decision the first time.

Some experts feel approximately 90% of the mistakes made by managers are judgments and decisions about people. They stress the importance of screening and evaluating candidates for hire or for promotion carefully. They also stress the proper and effective use of the motivators and incentives [Hensey, 1987].

The selection of personnel is not as easy as it once was. This is one of the areas many of the construction managers and

contractors feel the government is over-regulating the industry in. Only some of the potential problem areas that affect employment are:

Equal Pay Act
Civil Rights Act of 1966
Immigration Reform and Control Act
Race discrimination
Sex discrimination

The list of regulations affecting the employment of personnel is staggering and very restrictive. The idea is to avoid all these problems by finding the right people to start with. There are many means to finding the right people and the level of effort expanded in finding the right person will depend on the level of the position to be filled. The construction manager must weigh the level of effort and be very effective in judging human character.

Some of the things the construction manager needs to look for in selecting and interviewing people is attitudes, skills, communication ability, and knowledge. All of these traits add up to reflect upon the project productivity. The construction manager, as the interviewer, must be careful not to immediately decide about a candidate and then look only for confirming information. To avoid pit falls like this it is usually wise to have multiple interviews and have someone else participate. Normally, it is beneficial to have a younger assistant participate for several reasons. First he learns how to conduct an interview and gains knowledge from the experience. Secondly there will be a second opinion that you can use if desired. Always hire with a test period, which protects both you and the

new hire.

The hiring of construction laborers obviously will not be conducted on the scale mentioned above with the construction manager or contractor unless the company is very small. Therefore, it is extremely important that those doing the hiring fully understand your desires for the type of people hired, the traits, attitudes, and skills.

The promotion of people is just as important as the hiring. The project productivity is directly related to the people selected to run the project. After all, to repeat an old saying "it is managements responsibility". Construction managers faced with promotional decisions must carefully evaluate the candidates demonstrated abilities to determine who will function best in a position of more responsibility. This careful evaluation of the candidates emphasize the importance of the annual or quarterly evaluation system that you need for your employees. It is the written documentation of the performance over time. The evaluation over time is used so the promotional decision is not made on who performed best last week. Some employees are very skilled in knowing when to perform in front of the boss right before promotion time. It is flattering for the boss, however, can lead to a big mistake and lots of bad feelings within the organization. Some of the traits that need to be evaluated for the selection of people on the construction management team are:

Communication skills
Leadership ability
Interpersonal relations
Written skills
Stress tolerance
Professional knowledge

The list is considerably longer but one gets the point.

The selection and promotion of project personnel is paramount to the project productivity. The construction manager is the master of his destiny with the project team he selects and promotes.

CHAPTER FIVE

CONSTRUCTION MANAGERS PLAN OF ACTION

INTRODUCTION

This chapter is devoted to developing a plan of action for the construction manager to use for increasing productivity on construction projects. It will use the concepts, terms, definitions, and theories presented throughout the paper and combine them directly and indirectly into an 18 point program for the construction manager. The development of a plan of action and a set of procedures is necessary since the construction manager has a hundred different activities happening all at the same time. The old saying, "can't see the forest through all the trees", is very appropriate. Many of the programs points will require the direct attention of the construction manager and some will require only his support.

The construction manager has a lot of problems in trying to implement any new program and the number one is he must have the right mental attitude. The construction manager's attitude will set the attitude for the project. Attitudes have a direct relationship to productivity. Attitudes are also important since they can be indicators of the quality of life at work and of the worker's satisfaction. In the proposed program, it is more likely to obtain a good attitude since a productivity increase is directly linked to higher profits for a current on going job. It is more likely to convince the owner if it will keep project cost down. The laborers will have the right mental attitude if the program is presented correctly by management, since they also

benefit from higher productivity through better employment. Also tangible benefits for the laborers must be made by management to achieve their participation.

Prior to the implementation of the productivity program we must set the productivity measures of progress. Since there is no single best answer for all situations it will suffice to say that the construction manager will set the productivity measures prior to the start of the project using which ever productivity measurement option fits best.

The construction manager, as we stated earlier, is defined as the professional project manager. Responsible to the owner for the completion of the project, responsible to the construction industry for a professional job, and responsible to society for producing the most cost effective project for the resource inputs. The construction manager is with the project from the beginning working with the design firm and the owner through construction. He should provide leadership to the construction team and the management team; making recommendations on design, construction, schedules, and the economy of the project [Scott and Showalter, 1986].

18 POINT PROGRAM

The mainstay of the 18 point productivity program is the simple idea of productivity through people. Productivity can be achieved through hard work, smart ideas, loyalty , and numerous other human means. There are a hundred success stories of companies that started their path to riches through people productivity programs. The IBM tower is a monument to this

concept. IBM is only one on the list of large companies that made it to the top through people productivity programs [Peters, 1982]. The concept of treating laborers like compressors is a non productive concept and must be left behind. Sometimes this is hard to do in the construction industry due to the nature of the business but through proper planning it can be achieved in most cases.

The 18 point productivity program is not a checklist of items to be measured and forgotten as they are completed. It is more like a method approach with attitudes and ideas that the construction manager can implement in his particular circumstances if it fits. The program is a reminder of the simple things that we all forget when things get busy and our vision is clouded by the daily crisis of construction. The following is a list of the 18 points that will be covered in the program:

COMMUNICATION
LEADERSHIP
PRE JOB SET UP
SELECTION AND PLACEMENT
TRAINING AND EDUCATION
GOAL SETTING
MANAGEMENT BY OBJECTIVE
SUPERVISORY METHODS
SAFETY
APPRAISAL FEEDBACK
DECISION MAKING TECHNIQUES
CAREER DEVELOPMENT
ORGANIZATIONAL STRUCTURES
FINANCIAL COMPENSATION
PHYSICAL WORKING CONDITIONS
WORK RESCHEDULING
WORK REDESIGN
JOB SECURITY

The first item in the program is **COMMUNICATION.** Communication is a major element to a successful project and a

successful productivity program. Communication includes oral and written, formal and informal, and various other subtle forms of communication. Communication includes the passing of an idea whether through blue prints and specs or through directions and suggestions. It must be precise, accurate and timely with the correct method of presentation.

An example of how poor communication can lower productivity is the lack of timely engineering answers. The engineering answers that come from the home office to the project laborers in the field is rated by the foremen as a major demotivator for the crews [Borcherding, 1980]. It is a delay in productivity, and a form of communication problem. The telex is too slow, or the engineering department is too slow, or the paper work to get the answer is too slow; somewhere there is a communication problem. The examples that can be made of poor communication on the construction job site could fill a whole series of books. The solution to the problem is not easy.

First you must make the simple breakdown of who you are communicating with. The simplest list is the client, the contractors, and the laborers. The responsibility of the construction manager to communicate should by very extensive and formal:

1. The construction manager should establish a communications system with the client. A setting up of a systematic procedure for exchanging and documenting information, and reaching agreement on the kind and amount of information needed and the frequency with which it is to be exchanged.

2. Establish a communications system within the project team; that is, setting up a systematic procedure for exchanging information between the project team members.
3. Set up and monitor the adherence to the channels established and revise as necessary.

The next task is to set up the channels for communication, to all the different departments and interest. Put it in writing, publish it to all concerned, so it is clearly understood and available for use. The different channels to link the client, contractor, and laborers might be all or just some of the following:

Newsletters
Tool box talks
Foreman Delay Surveys
Meetings
Letters
Memo's
Walking tours
Suggestion Box
Open door policy's
Conferences
Contracts
Design Documents
Phone calls

The methods are up to the individual construction manager, but the principles are the same and should be well defined and published.

The use of communication on the construction job site can never be over utilized; it is a major source of information and planning material. The correct set up and use of communication channels will lead the project to success and its improper set up and use can lead the project to failure. The construction manager must like to communicate with people and organizations,

it is his business to link them all together professionally. He must be able to perform in informal settings as well as in large conferences with prepared presentations. The construction manager must be able to communicate well with everyone.

The next element of the productivity program is **LEADERSHIP.** The leadership we are referring to is that of the construction manager. After all, he is the focal point of the construction project, he is the continuity from conception to completion. The topic of leadership in construction has received alot of attention in the construction management professional journals lately. It is seen as another way to improve job site performance which is another measure of job site productivity. The steady hand of a good leader is invaluable to a construction project. The productivity gains of a good leader are not easily measurable because the problem of standards and definitions. The record of the good leaders, meaning the best preforming construction managers, will have to stand for themselves since the productivity levels recorded are lost in the sea of confusion regarding productivity measurement.

The best leadership style has been a topic of argument for centuries. There are numerous studies with conflicting results about task oriented leaders verses people oriented leaders. A recent study in England set up Fiedler's LPC Scale, which examines any association between site managers orientations and performance, across the range of situations encountered [Bresnen, 1986]. The answer to the age old question about leadership styles will not be answered easily. The secret is to use the one

that best fits the individual construction manager's style. If his style is task oriented that is just as fine as the people oriented style. The construction manager can mix the styles to suit his taste in leadership, but he must be consistent. To many, leadership comes naturally and they have no problem. Some construction managers must learn a leadership style which is not impossible; however, this takes alot of time and lessons that are usually learned the hard way.

The construction manager must like to lead and make decisions if he is going to be a successful project manager. With his ability to make decisions along comes the responsibility of those decisions. The productivity on the construction job site is a direct result of the construction manager's leadership.

PRE-JOB SET UP is another point in the productivity program. The pre-job set up is extremely important to the construction project productivity rate. The time to set up the job correctly from the start should be added into the project schedule. The owner should be heavily involved since the emphasis of the decisions will greatly affect the budget for the project. The pre-job set up will determine the construction productivity rates, the numbers of laborers, the quantity of tools available, the procedure for checking them out, the number of trucks, site layout for efficiency, and a whole array of other factors.

In this phase is the all important selection of personnel which as noted earlier demonstrated its own importance. The selection of personnel is not only the office staff but also any laborers that will be working for the construction manager

directly such as inspectors.

Each project has an infinite number of ways to be constructed and completed. It is up to the construction manager to investigate the different paths to completion and recommend the best for his talents. The pre-job set up includes ideas such as investigating the constructability and adding in the comments of others, if applicable. There are numerous ways to help select the construction site pre-job set up which will optimize the situations present. It can be done through computer simulation of the construction job site using programs such as Cyclone, and SLAM II. It can be done by using operational research techniques [Parker, 1972]. Or it can be done by the most common practice and also the cheapest method (at least initially) by experience. The construction manager always relies on his past experience to help set up the current project.

The time taken and money spent of investigating the construction job site set up is well worth it. If just one costly mistake is avoided the money and time are made up for. The problem is that you never really can prove that a mistake was avoided. You cannot show an increase in the productivity rate since there is nothing to compare it with. There are no industry standards to show how much better you're doing. The one indictor that you might use is the total project cost per square foot. Even this is hard to use since, for example, each building may have the same square foot but the insides are completely different. One is all open floor space and the other has offices constructed. The total project cost per square foot is not

easily comparable.

In the rush to start and complete a project the construction manager must slow down and take the time to do a proper pre-job set up. He must choose the correct procedures and have them ready to implement upon the start of construction. Once a project starts and you then try to go back and implement the procedures, it is a nightmare. The construction manager must set the construction job site up correctly from the beginning, with the correct manning, layout, and various other details. Pre-job set up is a vital part of every construction project so do not ever short change it.

The **SELECTION AND PLACEMENT** of people was mentioned several times already and deserves a quick re-emphasis. There have been several studies on the effectiveness of using selection and placement as a means of increasing productivity [Guzzo, 1983]. The findings of the surveys and studies confirmed if management made the proper selection of employees, the turnover rate decreased which is directly rated to productivity as shown earlier.

Selection is an administrative act involving the identification of personal variables that influence performance. If the organization is to reach its objectives, it must recruit those individuals possessing the desired characteristics. The placement of individuals in the organization is the judgment of the construction manager. He must maximize the outcome of the organization, which is to say he must maximize the productivity of the organization through his people. It is the selection and

placement of these people that set the productivity rate within the organization. The problem returns as usual to the measurement of the organizations productivity.

The methods presented in Chapter Four should be applied when ever hiring an employee whether it is an engineer or a clerk. A bad attitude in an organization, no matter what level, will place undue stress on the organization. Selection and placement of employees play's a significant role in productivity.

The **TRAINING AND EDUCATION** of our employees is another important part of the productivity program. The training and education referred to is that of the current employees. It is the clerks, laborers, engineers, and construction managers. The training is both in-house and by professional institutions. The Business Roundtable has recognized the need for proper education and training of our construction professionals, and recommends the institution of programs in each organization [Summary, 1983].

Presented first is information about the education provided from professional institutions. For the engineers and construction manager this almost always means college. The days of self made engineers and construction managers is coming to a close. The new trend is toward higher degrees as a means of advancement in the professional field. The educational programs for supporting and developing the construction managers are improving and growing in number [Scott and Showalter, 1986]. The engineers who are fresh out of school and going into the construction management area need the chance to study and advance their knowledge not only with field work but also in school.

Everyone interviewed agreed that the construction project manager has to have the field experience to base his decisions on. The project superintendents do not feel as strongly about the need for school education. This should not come as a surprise to anyone. Those teaching the construction management curriculum must have the ability to pass their field experience onto the students. Construction management is not a totally precise science yet.

The in-house training programs vary from company to company. Companies like Bechtel have very extensive in-house training programs. Completion of the in house programs are just as important in many instances as a college certificate. Mr. Griffths, interviewed earlier, had attended approximately ten lengthy in-house training courses. The smaller companies that can not absorb the overhead involved in company training programs must resort to other methods. Such as trade schools to the more promising laborers. A very important area of in-house training is the training of the new foremen. The Business Roundtable has emphasized the need for the correct training of foremen in leadership and other areas. The foremen makes a big jump when they become the leaders of a crew or the leader of all the crews. They have the technical knowledge but some have never had the fundamentals of leadership, management and personnel relations taught to them. The role of the foremen on the construction project site is to important too skip over the training required to make him a top performer. The foreman is the main link between management and the crew member, and he must

be able to work in both roles. The construction projects productivity rate is dependent upon the foremen's abilities as a leader and a manager.

The Business Roundtable has published a very extensive "Supervisory Training Program" handbook through the construction industry cost effectiveness project [Report A-4 Supplement, 1982]. The hand book is available by writing to the address in appendix A.

As we have discussed in great detail the problems associated with productivity measurement; without the measurement it is hard to define how we are doing. One of the techniques is **GOAL SETTING** which part of the 18 point productivity program. There are means by which to set productivity rates and goals. They are not consistent from project to project and often not even consistent on the same project.

Goal setting involves setting of performance goals. Goal setting continues to be viewed as an influential factor in improving productivity. Empirical studies support the contention that setting specific goals and objectives for future performance leads to increased motivation and performance, since goals can serve to motivate behavior. Goal setting serves to increase motivation by specifying particular work behaviors that will be rewarded.

A variable which received a great deal of attention in goal setting experiments was that of participatively set goals versus imposed goals. Much of the research utilized one of these two methods, often focusing specifically on the contrasts between the

two methods of goal setting in promoting organizational effectiveness. The method of setting the goals cannot be separated from the project cost accounting. If you estimated so many blocks laid per day, but the goal set by the crew is different, something has to be changed. The check and balance system must be used. The collection and manipulation of the data required to set up the cost accounts and the original estimates must not be forgotten by the construction management staff and left only to the cost engineers.

Another variable under study was the duration of goal setting effects. Such results were obtained in experiments by collecting performance data at several different times after goals were set at work. As expected, the effects of goal setting were stronger immediately after the initial goal setting than after 9 to 12 months had passed.

Goal setting is a valuable tool to the construction manager, it keeps the crews participating in setting the goals, it acts as a double check with the original estimate and the current schedule, and it increases productivity. Goal setting, once established, should be renewed on a regular schedule with incentives for meeting the goals and a course of action for missing them. The goals must be reachable but not easy. The human behavior changes from the desired behavior if the goals are unrealistic or arbitrary.

MANAGEMENT BY OBJECTIVES (MBO) is very similar to goal setting and also has a powerful directing influence on behavior and productivity. Management by objectives is a sophisticated

management technique which makes use of an objective setting and other devices to guide and control work behavior. The majority of the Fortune 500 companies manage their major division by objectives.

MBO permits the objective assessment of performance and allows the employee the opportunity to achieve rewards when goals are accomplished. At each level in the organizational hierarchy, specific goals are set jointly by the construction manager and the foremen whose future performance could be guided by them. Subsequently, the construction manager or someone on his staff will deliver behavior related feedback specific to performance objectives. The difference between goal setting and MBO is that goal setting is without reference to performance appraisal. MBO takes more time and effort to implement.

The biggest problem with the use of MBO is the number of different people associated with any one construction activity. One of the participates can be solely responsible for delaying the construction activity yet the objective will effect everyone measured by that activity. The goals set must be geared, as much as possible, to a single crew or flexible enough to account for other delays.

The use of goals no matter which method you use is extremely important. It makes the crew feel like they are part of the job and responsible for the outcome, which they are. It gives the crew an achievable goal in the near future which they can work to accomplish. If you make the goals too far apart the attitude will develop that they can make up a slow work day later and

still meet the goals. Unfortunately, this is very seldom the case. The use of goals is another method designed for increasing productivity and is very useful in the construction industry.

Another important part of the productivity program is the **SUPERVISORY METHODS** used by the construction manager and the foremen. Supervisory practices should be designed to ensure that organizational goals are achieved through the facilitation of the laborers performance. In effect, the needs of the organization are communicated down along the means-ends network, the chain of command, and the final result is that the individual is presented with a set of both implicitly and explicitly stated expectations or orders to be utilized in structuring subsequent job behavior. The supervisory methods include many of the points already mentioned such as communication, leadership style, and goal setting. None of the points in the productivity program are mutually exclusive.

Supervisory methods of productivity need not be interpreted strictly as involving "top down" directives in order to enhance output. Recently, productivity programs which alter supervisory methods by increasing the participation of laborers at work have received much attention. They use such ideas as the use of representative committees and labor management committees, as well as work forums.

Supervisory methods play a particularly important role in construction since the supervisors and foremen are consistently directing the laborers in their activities. Proper procedures and attitudes by the foremen and supervisors will go a long way

in improving productivity. This relates us back to training and education. Most foremen do not come with the techniques and sophistication required to jump in with the knowledge required to make productivity improvements overnight. The foremen that are lucky have training available.

SAFETY on the construction job site is an important part of any productivity program. It requires managements utmost support and attention. All safety programs relate back to goal setting, training, communication, and just plain common sense. Normally, the companies that have achieved success in those areas have also developed a good safety program. Safety relates directly back to productivity and on both sides of the productivity equations.

The laborers productivity and performance normally go up through loyalty to an employer they feel is watching out for their best interest and absenteeism goes down. As many surveys have shown one of the causes of absenteeism are dangerous working conditions.

The cost of construction goes down because the contractor can offer lower bids when he has a good safety record since his insurance costs are less. Not to mention no lawsuits pending because of neglect, or the cost of an OSHA fine. The cost of implementing a good safety program is minimum compared to the returns. It is up to the construction manager to make sure the safety program is strong and being used. The cost of poor safety programs to the owner and the construction industry require the construction manager to be on top of the situation. The construction manager should have the background and education to

at least be familiar with the requirements of a good safety program. It is the construction manager's moral obligation to be safety conscious.

The **APPRAISAL AND FEEDBACK** processes are essential to the survival of the organization and its productivity. From a general systems perspective, feedback means that some knowledge of the employee's performance is returned to the employee and acts as a stimulus to further performance. Positive feedback signals the employee to increase performance, negative signals just the reverse for most laborers.

A number of human behavior theories have pointed out that individuals desire and actively seek out feedback about their performance. It aids them in their quest to better understand themselves and their roles in the organization. The performance appraisal interview represents an opportunity for the employee to receive such feedback from his supervisor. Laborers also can acquire feedback through the self monitoring of performance and through access to summarized productivity reports and summaries of the time cards. Not all employee's are interested in monitoring their performance so do not count on a big demand for productivity reports. Most, however, are interested in the construction manager's opinion on how they are doing. Feedback can be as simple as; you're doing great, we're on schedule.

The Foreman Delay Survey reviewed earlier is a form of appraisal and feedback from the foremen. It makes up for the lost chance of face to face communication since the number of hours in a day are limited. It uses a source of information that

is very important to the construction manager. The gains in productivity from appraisal and feedback will not come overnight and may not be that noticeable since our measuring techniques are not that precise normally; however, the time invested certainly won't hurt productivity any.

The **DECISION MAKING TECHNIQUES** that the construction manager uses greatly affects the productivity on the construction job site. Decision making is the act of selecting a conclusive course of action from among an explored set of alternatives. It is the construction manager's job. Construction managers, more than any other workers, are employed to make effective organizational decisions and are evaluated on their ability to do so. Many people feel that decision making is synonymous with managing. The techniques for making those decisions are very different.

The use of expert systems is an upcoming means of decision analysis. In the end it is still the construction manager that must make the final decision and the decision on what is programed into the expert systems. The weights and balances assigned to different variables by the construction manager must come from experience. The advantage of the computerized expert system is once the expert has programed in all the knowledge he has the less knowledgeable and experienced can use it to aid in the decision making process. The construction manager can never give up his ability and intuition in the decision making process. He can be aided by man's new inventions but not replaced.

The process of decision making has also changed in its

continual search for methods to improve productivity by increasingly looking for input from groups and laborers. Many construction managers have joined the group of managers that feel the laborers on the job site know their job the best and often have the best ideas for increasing productivity. This is not a blind faith of the laborer but more of an awakening to a relatively unused source of information and insight.

CAREER DEVELOPMENT is a very important motivator for some employees which effect the productivity rate of many employees. Career development is the process by which an organization promotes its employee's growth inside the organization. This might involve career counseling or planning. The human motivation factors were previously discussed as a form of productivity improvement. The career development within the construction industry is an important part of productivity. The career development idea is not new to either unions or open shops since the level of each craftsmen is watched and the pay is based on the level. The promotion to foremen is always a proud achievement.

The promotion of employees in the same company has many benefits and many drawbacks. The benefits are knowing you have a given performer and a known quantity. If the selection for promotion is popular among the laborers or at least not unpopular the laborers can see the possibility for advancement and an improvement in living standards. The drawbacks come if the promotion is not popular or someone's feelings get hurt because they were not promoted. This is true in both blue collar and

white collar surroundings. The office and field politics are very important when making advancement.

Career developments can also mean other things besides just promotions. It can be selection for training programs, new job descriptions, and new responsibilities. Not all laborers are achievers and many are not interested in career development, but many are. The use of career development is an effective productivity tool for those laborers and employee's that are motivated by the possibility of advancement and career development.

The **ORGANIZATIONAL STRUCTURE** of any group or company plays a big part of the productivity of that organization. The structure of an organization represents a pattern of relationships, especially authority and functional relationships, among organizational members. Each organization has a formal structure which is composed of written documentation which provides employees with specific instruction or policies. Each organization also has an informal structure which is a pattern of relationships developed through the human contact of the individual members.

Both the informal and formal structure of an organization are dynamic. This is natural since people and organizations evolve with time. It is also natural, in the search of greater productivity, that organizations and people change. The best example is the recent philosophy of getting lean and mean to lower overhead cost. Lowering overhead cost increases the productivity rate since the input side of the equation is lowered

while the output side of the equation remains the same. The organizational structure of construction companies is not standardized nor is there any evidence as to which one is the most productive. The subject of organizational structure is an area of great interest since each company is always looking for the optimal structure.

The use of **FINANCIAL COMPENSATION** is used widely in the construction industry as a form of incentive for productivity increases. Incentive pay is typically thought of as performing a number of functions that contribute to organizational effectiveness. Primarily, it is considered a reward that can be used to make employees feel satisfied with their jobs, motivate them, gain their commitment to the organization, and keep them in the organization. For example, profit sharing programs have been installed in increasing numbers, exemplifying heightened awareness on the part of the organization of the potential for employee commitment to an organizational end of great importance, profit.

Monetary compensation in the construction industry often serves as positive reinforcement, contingent upon the performance of desirable job behaviors. The desirable behaviors are often set by goal setting, MBO type programs, and engineering standards developed by the construction management staff. The chore in all this is measuring the work-in-place with the productivity rates set and the means availible by which to achieve them. If you set a goal of 500 lineal feet of trench in two days and the crew makes their goal, but at the expense of

abusing the equipment, you have to question the goals you set; the goal of installing material quickly is normally at the expense of greater waste of material. You must balance the goals and make the financial benefits measurable so the laborers know it is not just another joke.

Financial compensation cannot be a "give me". The merit system and goal system must be obtainable but above the expected. The regular pay of laborers and employee's is not for just showing up and standing around and financial compensation should not be a regular add-on to the pay. It is a reward for superior performance, and can lead to great productivity by laborers and crews for short durations. It is not a permanent increase in productivity.

Many studies have been done on the productivity effects of the **PHYSICAL WORKING CONDITIONS.** Physical working conditions include such things as: noise levels, illumination, and site layout. The studies have been for both white and blue collar workers and as detailed as the design of chairs and office layout. The studies done for the blue collar workers have centered around manufacturing. The physical working conditions on the construction job site have gotten some attention from the stand point of workability, not really desirability.

The simple things such as having enough clean portable heads is very important for productivity. If there are no heads around for use or if the heads are trashed, the laborers will stop work and find somewhere else to go. Time away from the job site is very unproductive. Some of the estimates made recently state

that less than half the work day is spent in direct labor. Whenever we can eliminate a source of off the job time it will help productivity. The example of portable heads is only a minor example of the possible productive changes the construction manager could make in the physical working conditions at the construction job site.

The physical working conditions on any construction job site effect the productivity of that project. The time and effort involved is minimum, it is more a state of awareness that is required to see any problems with the physical working conditions. A good suggestion box may help locate any serious problems. As with all suggestion boxes, you must sort out the jokes and find the seriously submitted suggestions.

WORK RESCHEDULING is something the construction industry has been doing for ages; however, not in the way it is intended these days. The work rescheduling that could help in the productivity and motivation of the construction laborers is hard to arrange since construction is a team effort. The work rescheduling that the sociologist suggest is transforming the traditional 5-day 40-hour work week into a more flexible, variable schedule. Increased use of flexible scheduling which permits employee's time to cope better with non-work problems during work hours. Developing a "core" time period of a few hours each day when everyone must be there.

As stated, this is hard to do since the average construction project takes alot of team work and coordination. There are certain areas where this can be done but it does take alot of

coordination by the construction manager. An example, such as having crews that work in the same area work swing shifts, or some laborers start a few hours early for getting tools and material ready and others start a few hours later for job clean up this way the project is worked longer hours but each laborer only works eight hours.

Work rescheduling is even harder on union jobs because of the work rules set up by contract. The use of work rescheduling as a means of improving productivity is possible but it does take alot of the construction manager's time and effort. It should be evaluated on a case by case basis.

The next point in the program, **WORK REDESIGN,** has not received much attention in the construction industry but has had a major impact in the manufacturing industry. The design of a job can be described as a specification of job content, method, and relationships in order to satisfy the technological and organizational requirements of work as well as the social and personal requirements of the job holder. In recent years, it has been recognized that jobs were often designed with emphasis on technological requirements and ignorance of human requirements in the manufacturing industry; resulting in worker dissatisfaction and low productivity. A strategy for overcoming the effects of ill designed jobs is to redesign them in a way that is more conducive to better worker performance and enjoyment of work.

The construction industry will need to review the studies and lessons learned in the manufacturing industry since the construction industry will have to become more automated in the

future. The problem of laborers job satisfaction has been less in the construction industry than in manufacturing due to the nature of the work. This will change with the introduction of robotics in the construction field. As men are replaced, their job descriptions will have to be rewritten and redesigned to provide satisfaction. If we implement the changes correctly from the start, we won't have to repeat manufacturing mistakes and suffer the resulting productivity decline.

Some of the problems with work redesign can be eliminated through the education and training of our employee's. Some of the crafts will change, such as the masons with the introduction of the machines that can lay block quicker and cheaper than the masons of the near future. The displaced masons must have their jobs redesigned to provide satisfaction and keep the productivity improvements that the machines offer.

The final point of the productivity program is also one of the most important. **JOB SECURITY** is on a lot of peoples minds these days with layoffs and automation in the construction industry. It includes laborers and engineers, and does not know any geographic bounds. The construction industry is a anomaly. We work very hard to work ourselves out of jobs. The quicker we finish a project the sooner we can look for another job. There is a real problem with this, and it can be seen often at the end of a big job when there are no more jobs to be had. It is often hard to finish a big job because the laborers do not want to finish because there are no more jobs in the area. You cannot blame the laborers for not wanting to finish and go on

unemployment.

Job security of the laborers does not effect the output at any given moment but does effect the productivity in the long run and towards the end of a project it effects the productivity in the short run. The people programs center around people and, which in construction, eventually centers around job security. Due to the nature of the business, you cannot hire everyone as a permanent employee that works on a job; but you do not have to hire everyone as a temporary employee either. The construction companies are starting to follow the examples of the manufacturing companies such as IBM. The Bechtel Corporation is trying to be more sensitive to the needs of its employees during lean times in the construction/engineering business.

Job security often leads to loyalty and other favorable human traits which lead to higher productivity. An organization that prides itself on people programs normally attract the best people and; therefore, develop the best reputation that attracts business. Its through the employees that a company develops its business since any business is no more than its employees.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Our understanding and research of the productivity problem in the construction industry is actually very good. The studies being performed by various educational and research institutions are commendable. The organization and structure formed by the Business Roundtable and the productivity centers is becoming very efficient in the distribution of information, highlighting the problems, and increasing the awareness and knowledge of the industry. In the final analysis, it is the implementation by the individual company and contractor where we are not doing so well. The solutions and ideas to improve construction productivity have been in the works since before the turn of the century but we are slow to follow them and still cannot measure the change accurately or consistently even if we implement them.

This is not to say that some companies have not taken great steps forward in their technological advances. The problem is the technological advances which lead to productivity advances are far behind the advances in wages and benefits. How far cannot be determined since there is not a good standardized system for the measurement of construction productivity. Even the calculations of the total dollar volume are significantly wrong. The problems are compounded by the fragmentation and competitiveness of the construction industry.

In reading the Business Roundtable reports and studies it becomes apparent that the members of the Business Roundtable felt

the only way to control and effectively regulate the construction industry is through the owners and clients; hence is the growth of the construction management business. The dissemination of the information and recommendations of the Business Roundtable has been slow to the owners and clients but it is spreading and so is the use of the construction manager philosophy. Steven Bechtel Jr., president of the Bechtel Corporation and a member of the Business Roundtable, on a recent field visit to the Oak Ridge Office voiced the same concerns and ideas.

The problem of standardized construction productivity measurements on a large industry wide scale is still a formidable problem. The government still will not release its figures on the construction industry because of inaccuracies and the construction industry does not keep any central records. The idea of breaking down the industry into smaller segments for reporting has been tried in that the industry reports separately the industrial, commercial, residential, and highway construction. Unfortunately this has not solved the problem.

The problem of project level productivity measurement is much more simple but still a problem. Even projects of similar construction often use different measures of productivity because of client preferences or because of contractor preferences. The trend for standardization of company wide productivity measurement is at least looking favorable. Many of the companies interviewed use a standard measure for each craft, and are attempting to standardize the productivity measuring system between projects. The construction manager will have to select

the productivity measures he feels will be the most useful and constantly stay with it. This has become easier with the advent of the micro computer because even standardized information can be quickly manipulated into almost any desired form.

The governments role in all this is multifaceted, starting with adopting some of the Business Roundtables recommendations on recording and reporting construction industry figures. The government has started in the right direction and is working on improving the techniques used in the productivity measurements.

The government also needs to review the mound of regulations placed on the construction industry and decide what can be combined and eliminated wherever possible. This act is not easy since many federal and state jobs are associated with the regulation and governing of the construction industry. The construction industry can help with continued studies on regulation and report its findings to the federal and state agencies. The governmental agencies must create a central point to receive the recommendations and evaluate them, otherwise any changes must slowly make their way through the congressional channels. The changes made through congressional channels are always subject to lobbying pressures by various groups. This is another front where the construction industry can help its productivity by being more aggressive in the lobbying arena.

The subject of productivity in the construction industry touches every part of our daily lives. It is a very broad topic which stretches from the productivity of a single individual laborer to that of the largest industry in the United States.

This paper has presented an overview of productivity in the construction industry from several different perspectives, that of the activity, the project, and up through concerns of the industry in general. The paper has also presented a 18 point program to be used to heighten the awareness of the construction manager and the project team.

RECOMMENDATIONS FOR FUTURE RESEARCH TOPICS

In the course of writing this paper it became apparent that there are a great many topics that pertain to the subject of productivity in the construction industry that still need research and investigation. The following is a list of possible future research topics:

1. The use of video camera's for time lapse productivity measurements.
2. A study of "white collar" productivity in the construction industry.
3. Standardize a list of construction productivity units that can used for all segments of the construction industry. Develop a method for assigning weights to the individual productivity rates so they may be combined into a single project productivity rate that can be applied across the spectrum of projects.
4 Research the use of productivity data in claims and legal proceedings and how current collection methods effect the outcome of the proceedings.

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APPENDIX A

LIST OF RESEARCH INSTITUTES AND PRODUCTIVITY CENTERS CONTACTED

AMERICAN PRODUCTIVITY CENTER
123 North Post Oak Lane
Houston, TX 77024 PH (713) 681-4020

THE BUSINESS ROUNDTABLE
200 Park Avenue
New York, NY 10166 PH (212) 682-6370

BUREAU OF LABOR STATISTICS
1371 Peachtree Street
Atlanta, GA 30367 PH (404) 347-4418

THE U.S. CHAMBER OF COMMERCE
1615 H Street Northwest
Washington D.C., 20062

CIVIL ENGINEERING SUPPORT OFFICE
Naval Construction Battalion Center
Port Hueneme, CA 93043

CONSTRUCTION INDUSTRY INSTITUTE
3208 Red River Street, Suite 300
Austin, TX 78705 PH (512) 471-4319

JAPAN PRODUCTIVITY CENTER
U.S. OFFICE
1901 North Fort Myer Drive, Suite 703
Arlington, VA 22209 PH (703) 243-5522

MANUFACTURING PRODUCTIVITY CENTER
10 West 35TH Street
Chicago, Illinois 60616 PH (312) 567-4000

APPENDIX B

LIST OF INTERVIEWS

Mr. Douglas Griffiths (615) 482-0307
Tech Services Manager
Bechtel National Inc.
P.O. Box 350
Oak Ridge, TN 37831

Mr. W. Park McNair (404) 264-3518
Group President
HARDIN CONSTRUCTION GROUP, INC.
1380 West Paces Ferry Road, N.W.
Atlanta, Georgia 30327-0404

Mr. Michael C. Ray (404) 239-0220
Manager Cost Management Services and
Construction claims Administration
PROJECT TIME & COST, INC
Sixteenth Floor, Lenox Tower South
3390 Peachtree Road, N.E.
Atlanta, Georgia 30326-1108

Mr. Homer Sherman
Project Superintendent
Bechtel National Inc.
P.O. Box 350
Oak Ridge, TN 37831

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